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Computerized simulation for teaching experimental design

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COMPUTERIZED SIMULATION FOR TEACHING EXPERIMENTAL DESIGN

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

Since the advent of the digital computer almost thirty years ago, man has been exploiting its seemingly inexhaustible utility. It was initially discovered that computers could solve properly formulated complex mathematical problems which had previously exceeded existing resources. Subsequently the business community discovered that the computer could efficiently do much of the menial work in the accounting and record keeping areas. As new applications were implemented, new techniques were developed, computers were refined, and thus additional applications were entered into the realm of practicality. This spiral has led to computer designed and directed spacecraft which have delivered men to the surface of the moon and brought them safely back to earth.

This is truly an amazing feat, but it does not bound the scope nor form the pinnacle of the computer supported "information revolution." Computers will be utilized in an ever increasing number of areas affecting an ever increasing number of people. David Sarnoff (23, p. 21) attempts to open a window into the future when he predicts:

> By the end of the century, for the equivalent of a few dollars a month, the individual will have a vast complex of computer services at his command. Information utilities will make computing power available, like electricity, to thousands of users simultaneously. The computer in the home will be joined to a national and global computer system that provides services ranging from banking and travel facilities to library research and medical care. High-speed communication

> devices, linked to satellites in space, will transmit data to and from virtually any points on earth with the ease of a dial system. Students, businessmen, scientists, government officials and housewives will converse with computers as readily as they now talk by telephone.

The realization of any sizeable portion of this ambitious prediction of the scope of computer utilization presents society with a complex challenge. And as usual, one of the segments of society which must assume a major responsibility for meeting this challenge is the educational system. The increasing use of computer technology will place increasing demands upon the curriculum which will, in turn, demand emphasis on economy and efficiency of instruction. Fortunately progress is already being made.

Computer science is being taught as a subject in many of the colleges and universities and some of the high schools throughout the country. In addition it is commonly used to facilitate the computational aspects of many other subjects, predominately mathematics, science, statistics, and engineering. Since 1958 when Rath (22) and his fellow researchers at IBM discovered that computers could be used to teach the properties of binary numbers, educators have been investigating the feasibility of using computers to teach a wide variety of units in a wide variety of subject areas. Thus, the computer is not only entering the crowded curriculum as a subject, but may through its instructional capabilities, alleviate much more pressure than it causes.

Rudiments of investigations into the instructional potential of the computer led Sarnoff (23, p. 21) to predict:

> Some of the most profound changes wrought by the computer will be in education. Here, the machine will do more than assist students to solve problems and to locate up-to-date information. It will fundamentally improve and enrich the learning process. . . . Computer-based teaching machines, programmed and operated by teachers thoroughly trained in electronic data processing techniques, will instruct students at the rate best suited to each individual. The concept of mass education will give way to the concept of personal tutoring with the teacher and the computer working as a team.

Dr. Patrick Suppes (27, p. 207) substantiates these views as he writes:

> One can predict that in a few more years millions of school children will have access to what Philip of Macedon's son Alexander enjoyed as a royal prerogative: the personal services of a tutor as well-informed and responsive as Aristotle.

An electro-mechanical system has not been developed which would teach a modern slave boy the proof of the Pythagorean Theorem in a Socratic manner nor is one likely to emerge in the near future. These "super extrapolations" by Sarnoff and Suppes can only be approached by a spiral of computer applications, particularly the educational segment of computer applications, sustained by the same patient, directed research which put the moon on travel maps.

As was indicated earlier, research into the instructional capabilities of the computer has already begun. It has roots in such areas as artificial intelligence, natural language translation, and information retrieval. It receives support from the programmed instruction movement, learning theory, gaming theory, and a wide range of previously established computer applications. The products of this research have appeared in four major areas: computer assisted instruction (CAI), computer managed instruction (CMI), problem solving, and simulation. Of these areas, CAI would appear to be the path to the electro-mechanical Aristotelian tutor with CMI being a pragmatic approach to the implementation of the current state of CAI. Problem solving and simulation are, for the most part, supplements to conventional instruction and vehicles for pedagogical investigations. Successful research in these areas will promote the use of the computer as an instructional media in contemporary classrooms and provide experience upon which future research can be based.

Computer assisted instruction is any on-line instructional process in which the computer and student engage in discourse designed to promote student learning. Most of the published work in this area is either drill and practice CAI, which is exemplified by a program developed by Suppes (27) to teach elementary mathematics, or tutorial CAI which is exemplified by the programs developed by the Commission on College Geography for the purpose of teaching topics in undergraduate geography (13). Drill and practice consists of student-machine interaction which is designed to provide practice on concepts and skills which a teacher has previously introduced.

Tutorial programs assume the responsibility for introducing the student to new skills and concepts. Both of these types of CAI have the characteristic that the lessons are machine directed. That is, the student is presented a series of questions or frames of information to which he supplies responses, as opposed to permitting a free dialogue between student and machine.

This indicates the need for a third area, a dialogue CAI, which permits the student to introduce freely structured independently formulated sentences to which the computer responds creating a two-way conversation. An example from this area is the ELIZA system which was developed by Weizenbaum (31). Although this program permits free student response it should be noted that the "understanding" of that response by the machine is at a very low level if in fact it can be considered to exist at all. This problem of man-machine and machine-man understanding must be solved before the computer can become an Aristotelian tutor. The solution to this problem would appear to be many years hence.

CMI is an economical approach to drill and practice as well as tutorial CAI. In this method the computer is used to grade, evaluate, and record the student's work and to prescribe the next lesson from a resource file or to generate it in printed form. CMI has gained impetus through efforts such as the individually prescribed instruction (IPI) program of elementary mathematics which was developed by Cooley and Glaser (14).

Problem solving is probably the most generally used method of computer supported instruction. It simply consists of programming a computer to solve a problem. By directing a computer to solve the problem it is reasoned that the student learns more about the problem and consequently more about its solution than he does by solving the problem through conventional means. In addition to this, and probably of more importance, the scope and magnitude of the problems which can be assigned are greatly increased, thus permitting more realistic assignments.

Computer simulations have been used extensively and successfully by the military and space program to train personnel; however, in spite of this simulations have not been widely utilized by the schools. In areas where they have been used, limited success has been reported. The reasons for this are unclear at this time; however, it has been conjectured that the effects of the simulations were not properly measured, that the simulations were improperly constructed or improperly used, and that they are not particularly well suited to cognitive learning. In any case, the utility of simulation as an instructional technique is not well defined. It is to a segment of this general problem that this research is being directed.

A. Statement of the Problem

The problem is to develop a computerized simulation to be used in teaching the strengths and weaknesses of research designs in the behavioral sciences. It should serve as a laboratory, promoting the enactive and iconic aspects of the theory presented by Campbell and Stanley (9).

B. Purpose of Project

The purpose of this project is two-fold. It is to provide a learning aid for students of behavioral research, and it is to provide a vehicle for researching simulation as an instructional method.

As a learning aid the simulation should:

1. enable the student to "play the role" of a researcher by performing experiments on a collection of computerized models,
2. permit the student free choice of experimental design by providing him with facilities to test, group and stimulate the models,
3. at the option of the instructor, alter experimental results in a manner paralleling the effects of the validity jeopardizing factors which plague actual experiments,
4. permit exact replications of an experiment, providing the researcher an opportunity to isolate and diagnose problems,

5. summarize the experiment, tabulate the results and provide elementary statistical analysis,
6. provide diagnostics for any structurally ill-conceived experiment.

As a research vehicle, the simulation developed by this project should:

1. permit investigations into the instructional value of simulation,
2. support investigations concerning the combined use of simulation with other instructional strategies,
3. provide insight into simulation construction,
4. support investigations related to student reactions to simulation.

C. Need

In discussing the theory of instruction, Bruner wrote (7, p. 72):

> A body of knowledge, enshrined in a university faculty and embodied in a series of authorative volumes is the result of much prior intellectual activity. To instruct someone in these disciplines is not a matter of getting him to commit results to mind. Rather, it is to teach him to participate in the process that makes possible the establishment of knowledge.

In the area of behavioral research, Bruner's statements are especially appropriate; however, achieving the participation he advocates is frequently quite difficult. In fact, due to cost, administrative problems, and time requirements, graduate students in this area frequently do not conduct experiments until the terminal phase of their program. Thus, in an area where the major effort is directed toward the establishment of knowledge the student is belatedly identifying with the role of the researcher. Simulation may provide an efficient, economical solution to this dilemma.

D. Outline of Subsequent Chapters

The material presented in this report has been organized into six chapters. The first chapter includes a brief introduction to the general area and an isolation of the problem. The second consists of a review of the literature related to the type of simulation which is being constructed. A description of the design including the philosophy of construction, hardware requirements needed to support it, and demands upon the user are discussed in chapter three. Chapter four contains a description of the implementation including a detailed explanation of computer programs and their organization. An analysis of the effect of modifying the various components of the system on its performance is discussed in chapter five, and chapter six is devoted to conclusions and observations made as a result of constructing or utilizing this experiment. Computer programs and flow charts are included in the appendixes.

II. REVIEW OF LITERATURE

A. Purpose of Simulation

Since simulation is a concept which is both extremely flexible and extremely popular, it has infiltrated the current literature of almost every discipline. Engineers and scientists report investigating the properties of proposed and existing systems by utilizing mathematical and physical models. Economists and industrialists describe simulations of economic and business processes as a means of gaining new insights into the rules governing these processes and as a means of communicating established knowledge within the field. Psychologists report the construction of models of human behavior which are used to establish and evaluate theories, while sociologists have produced numerous publications describing simulations of social processes used for instructional and investigative purposes. Simulation is a heavily used term in military and space agency reports since investigation and training in these areas are frequently impractical if not impossible to conduct in a natural setting. In order to construct complex models which remain operable, researchers of many areas have frequently utilized computers and subsequently reported their work in the publications of that discipline. In fact, several special purpose computer languages have been developed to support this approach.

In spite of this diversification of applications, Bushnell (8) isolated three purposes for simulating: analysis, development, and training. Analysis is to effect the study of an ongoing situation; development is to aid in the development and evaluation of a new design, system, or organization; and training is to train humans in new and old skills. These are not mutually exclusive categories since many simulations serve more than one purpose; however, they are interdisciplinary and if training is very liberally interpreted, appear to be complete. Many researchers believe that the instructional potential of simulations extend far beyond a skill development such as learning to drive a car or to fly an airplane.

B. Definition

Since the primary purpose of this project is to develop a learning aid, the literature reviewed is restricted to the area of instructional simulation. Even with this restriction, simulation has a variety of definitions. Cruikshank (15, p. 23) defined it to be game construction.

> Simulation may be defined as the creation of realistic games to be played by participants in order to provide them with lifelike problem-solving experiences related to their present or future work.

Guetzkow (17, p. 83) tends toward brevity by defining simulation as "an operating representation of central features of reality." Twelker (30, p. 47), on the other hand, used the shotgun approach.

> Simulation may be defined as: (1) a technique of modeling (physically, iconically, verbally, or

> mathematically) some aspect of a real or proposed system, process, or environment, or (2) the model (physical, iconic, verbal, or mathematical) of some aspects of a real or proposed system, process, or environment.

While these definitions illustrate some of the versatility and consequent confusion which surrounds instructional simulation, they also contain its essential features. They do not clearly determine whether it is a product or the technique of developing the product, is a model or a game, or consists of symbolic or physical parts. They do, however, specify that it is representative and generally agree that the target of representation is real. In addition, in order to maximize their instructional potential, simulations should be operational and should contain only the essential features of reality.

The distinction between a game, model, and simulation is extracted from _Of Men and Machines_ by Beck (3, p. 5).

> The difference between a simulation, model, and a game is simply that a simulation is a more inclusive simplified representation of some process that is to be understood by the student. A model is a theoretical representation of such a process, and a game is its formulation into a competitive activity among human players whose outcome is uncertain and whose outcome is decided by various combinations of skill, chance, and knowledge.

Coleman (11) sheds additional light on the subject by listing the following properties of games. (1) The players have goals toward which they act. (2) Permissible as well as non-permissible actions are prescribed by rules. (3) There is a higher order set of rules which specify the consequences of each action in terms of goal achievement. It should be noted that Coleman does not require or rule out interplayer competition; however, the existence of goals implies at least intraplayer competition.

From Coleman's properties and from the definitions it is clear that a game can be other than a simulation but it is not clear that an instructional simulation can be used in a manner which will prevent it from being classified as a game. The contention that an instructional simulation is merely a game harbors much of the criticism for its educational use.

For this project an instructional simulation is defined to be an operational representation or model of selected features of some real system, process, or environment. The features are selected in support of the educational objectives under which it is designed. The utilization and design philosophy determine whether it is a game. In order to encompass the literature all games, simulation games, models, and simulations which meet this definition will be considered to be instructional simulations and will frequently be referred to simply as simulations.

C. Simulation as a Learning Aid

1. Examples

Prior to discussing their instructional advantages and disadvantages, it might prove fruitful to briefly describe some of the simulations which have been developed. In order to provide a broad picture, an example has been chosen from each of the areas of school administration, social science, and business. The school system example called the "Jefferson Township School District" is described by Wynn (32, p. 171).

> The simulation materials include a 152-page comprehensive survey of the actual but fictionalized school system; a sociological study of the faculty of the elementary school under consideration; personnel records; chart of class sizes; school directory; achievement test results; school census report; staff handbook; annotated school laws, board statement of policies and by-laws; motion picture films and a slide film describing the community, the school system and the elementary school; several tape recordings extracted from school board meetings, administrative staff meetings, PTA meetings, parent teacher conferences; and many other relevant artifacts of the school system.

After five hours of reading and listening to this material each participant assumes the position of elementary principal and is presented a series of "in-basket" items to which he must produce a written response. These items include letters from parents, memos from the superintendent and other typical school problems. Following the reaction by the students, the problems and solutions are discussed in the classroom.

The social science example chosen is the Life Career Game described by Boocock (5, p. 108).

> The game is organized into rounds or decision periods, each of which represents one year in the life of this person. During each decision period, players plan their person's schedule of activities for a typical week, allocating his time among school,

> studying, a job, family responsibilities, and leisure time activities. Most activities require certain investments, of time, training, money and so on (for example, a full-time job takes a certain amount of time and often has some educational or experience prerequisites as well; similarly having a child requires a considerable expenditure of time, in addition to financial expenses), and a person clearly cannot engage in all the available activities. Thus, the players' problem is to choose the combination of activities which they think will maximize their person's present satisfaction and his chances for a good life in the future. In addition, for certain activities--a job, or higher education--a person must make a formal application and be accepted. (An integral feature of the Life Career Game is that in the normal course of playing, students acquire such skills as filling out college or job application forms correctly.)
>
> When players have made their decisions for a given year, scores are computed in four areas--education, occupation, family life, and leisure. Calculators use a set of tables and spinners--based on U.S. Census and other national survey data--which indicate the probabilities of certain things happening in a person's life, given his personal characteristics, past experiences, and present efforts.

A person's life is managed by a team of from two to four players. After the game has completed a predetermined number of rounds, the players whose person accumulated the most points are declared the winners.

Business games were among the first to appear and have become quite prevalent. Greenlaw _et al_. (16, p. 162) present a nonexhaustive summary of approximately ninety which were operational in 1962. X-Otol is an example.

> The X-Otol Simulation provides the participant with the opportunity of operating--and either applying decision rules or making decisions affecting--a process model of a multi-level, multi-phase dynamic flow physical distribution system. X-Otol is the

> brand name of the product being distributed. The X-Otol Simulation is designed for operation by a team of three persons, each of whom has a specific work assignment with precise instructions for the performance of his duties. With the game administrator assuming the role of all consumers, one team member takes the role of all retailers, another for all wholesalers and a third that of the manufacturer of X-Otol. Any number of teams can play at one time.
>
> The X-Otol Simulation involves the participants in a distribution system which behaves in the "crack-the whip" manner described above and presents them with the problem of dealing with and experimentally testing order and inventory policies; the basic objective is to avoid "stock-outs" while at the same time, controlling inventory levels. Varied customer demand inputs are programmed into the system and the impact of these is studied as the simulation proceeds. Chronological charts are developed during the critique of the simulation on such factors as customer purchases, orders issued by retailers and wholesalers, production scheduled by the manufacturer, and volume of goods produced by the manufacturer.

The last two examples are games while the first would not be so easily classified as such. This is probably not so much a result of design intent as of design emphasis. The Jefferson Township Simulation is closer to the real life situation. This characteristic is accomplished with a large expenditure of time required to present the detailed setting and through the absence of behavior constraining rules. In this simulation there is no optimal strategy and no inherent evaluation. As a consequence it places much more of a demand on the administrator.

2. Types

As viewed from the standpoint of strategy of use, there are theoretically two basic types of simulation, primary and supplementary. A supplementary type such as the Jefferson Township School District is intended to be used to supplement other teaching methods, while a primary type is designed to be used independently, or with a minimum of additional instruction. The Life Career Game is an example of the latter. The theoretical distinction can be made more explicit by considering the overall uses of simulations as summarized by Twelker (30). They are presenting information, eliciting responses and providing a situation for practice, and assessing performance.

Primary simulations are typically designed to include all three uses, with the student's behavior as described by Abt (1) to be self-directing and to occur in three phases. The student first learns the facts expressed in the game context and dynamics, he learns the process being modeled, and then he learns the risks and rewards of alternative strategies of decision-making. This type probably demands a higher degree of fidelity in order for the learning to be meaningful.

A supplementary simulation is frequently devoted to a specific purpose. It may be used prior to other forms of instruction to predisposition the learner, it may be used by the learner as an environment in which to practice, or it may be used after other instruction for evaluation or self-evaluation. Members of this group usually require less internal control, hence are easier to construct at the expense of being more challenging to administer.

3. <u>Advantages and disadvantages</u>

Proponents of instructional simulation suggest advantages which run the gamut of pedagogical desirables. Coleman (12), a designer and advocate of social games, indicates that these games provide an advantageous approach to learning since the student "discovers," as opposed to being "fed," knowledge; they provide students with an environment within which to make decisions; they are motivational; they allow the teacher the freedom of being an assistant to the learner as opposed to being judge and jury; and they develop the student's sense of control over his environment.

Snyder (25, p. 12), in discussing the teaching of international relations, observes that students "take simulation very seriously indeed and are capable of complete absorption." As a result he suggests that it may be superior to other teaching materials by making politics and national issues more meaningful to the student through the individual's personal experience.

Beck and Monroe (3), in comparing it with conventional methods, state that it is capable of providing experience in a wider range of educational objectives, causes greater transfer from training situations to real life, and gives the learner a sense of immediacy and involvement. In comparing simulation with direct experience they list cost, ability to compress time sequences, and low risk experimentation as favorable factors.

In summarizing the reported advantages of simulation, Alger (2) presents four generalizations. It heightens the interest and motivation of students, offers an opportunity for applying and testing knowledge, provides greater understanding of the world as seen and experienced by the decision-maker, and it provides a miniature world which is easier for participants to understand than are the real world situations.

Although the supporters of simulation are not in agreement on its primary advantages or uses they do concur that it is an excellent vehicle for pedagogical research.

Like other methods of instruction, it is not without its disadvantages. Beck and Monroe's (3) list of disadvantages include difficulty in achieving adequate fidelity to promote transfer, problems of validation, problems in training teachers, and cost when compared with conventional instruction.

Kraft (19), in discussing games for social science is much more critical. He states that they are frequently inappropriate because they distort reality. Since games have predefined rules and values, he believes they do not give students adequate opportunity to examine values and confront reality. He does not feel that the teacher's role as student evaluator should be diminished and he attacks the very roots of social games by suggesting that the students' sense of self-evaluation may be blunted and stifled by an overindulgence in these activities.

D. Some Research Results

As one would expect numerous attempts have been made to determine the pedagogical worth of instructional simulations. In comparisons with other methods the results have predominately been that no significant differences were found. Thompson (28) compared game playing with conventional instruction as a means of teaching junior college economics and discovered no significant differences. Strothers (26) concluded from an experiment conducted at the University of Wisconsin School of Business that students who participated in management games acquired no better knowledge of facts, were not more highly motivated, and had no different attitudes toward management and business than did students who were taught by other methods.

Cherryholmes (10, p. 4) combined the empirical data from six independently conducted studies in the social sciences to test the hypothesis that students participating in a simulation will: "reveal more interest," "learn more facts and principles of information," "retain information learned longer," "acquire more critical-thinking and decision-making skills," or experience a significantly different attitudinal change when compared with students in a conventional classroom. The hypothesis that "students participating in a simulation will reveal more interest in a simulation exercise than in more conventional classroom activities" was accepted while the others were rejected.

These studies, while not overly encouraging to the supporters of simulation, are not particularly discouraging either. For if they prove simulation to be no better than conventional instruction they also prove it to be no worse. This is a particularly significant point in view of the fact that simulation is relatively new and consequently should experience considerable improvement.

Observations made by early users are already appearing in the literature to serve as a guide to current designers and implementers. Inbar (18) suggests that group size and the person in charge have an effect on the success of simulations in the social sciences. McKenney and Dill (21) suggest that competitive aspects of management games detract from learning by encouraging students to play conservatively as opposed to experimenting with new strategies. Bloomfield and Padelford (4) suggest that role playing simulations are ineffective when there is a "knowledge gap" between the players and the requirements of the role.

Another consideration is that the full effects are not being measured. Schild (24) believes that the variables typically used for measuring learning are not related to winning but are dependent upon the extraneous aspects of the simulation games. Boocock (6) indicates that games may induce enactive and iconic learning but not symbolic representation. She also observes that students are frequently able to perform shrewdly in a very consistent manner but cannot explain what they do. This observation may lead to instructional strategy for the utilization of simulation as well as a more pragmatic approach to its evaluation.

E. Summary

Instructional simulation has a relatively short history, being a by product of World War II. As a result, it has been utilized in a smattering of areas for a variety of purposes, with moderate success. Both its pedagogical validity and consistence are open questions making it a versatile vehicle of research; however, research in this area has and will continue to be hampered by the fact that the art of teaching has developed beyond the science of evaluation.

III. DESCRIPTION OF THE DESIGN

A. Overview of the Simulation

The simulation consists of 130 computer models of students which can be used as subjects for experimentation. Each subject responds to teacher characteristics in the manner dictated by his parameters and the environment of the experiment. These subjects can be separated into as many as twelve groups, tested as frequently as is desired, and exposed to a variety of types of stimuli. Through selected use of these facilities the student of behavioral research can design and carry out a wide range of experiments. To make the experiment more realistic the instructor or administrator of the simulation can activate influences which modify the experimental data in much the same manner that validity jeopardizing factors affect real world experiments.

The input to the simulation is a coded description of the experimental design. The output consists of scores from the tests which were administered to the subjects during the course of the experiment. These scores are printed by experimental group along with group statistics such as averages, deviations from the group mean, average change from the previous test and deviations from this change. In addition a t-test statistic is computed, on request, for any two groups.

In actual practice it is assumed that an instructor using this product would present the students with a research situation and ask them to formulate and then test a hypothesis. As an illustration, however, of a possible use, the following hypothesis could be presented to the student for evaluation. "Teachers with high college academic records, pleasing personalities, and maximum interest in their fields are no more effective than teachers with low college academic records, a feeling of antagonism toward their students, and a dislike for the courses they teach." For this hypothesis the instructor might stipulate that two established classes are to be used in the experiment, with the teachers to be assigned by the researchers. Thus, two groups could be selected by the instructors which appear to be identical but which have significantly different parameters. Validity jeopardizing factors such as testing sensitivity, multiple treatment effect, testing, and experimental mortality could be activated.

Through a comparison and discussion of results the student should realize that the assignment of the teachers is a critical decision in which randomization is of no help. Students who use a complex design such as a time series design or who alternate teachers after a period of time should obtain evidence that testing and multiple treatments affect the results. The fact that several of the subjects fail to complete the experiment would raise the question of the significance of experimental mortality. In addition, the cost of the experiments could be compared.

B. Philosophy of the Design

It should be clearly understood that the models contained within this simulation are not intended to function either collectively or independently as students in the real world. The project is not a simulation of human behavior but a simulation of the environment in which behavior can be evaluated. The intent of this project is to extract the essentials of the real world environment and to assimilate them so that the procedures which are necessary to determine real world behavior are necessary to determine the behavior of these models. For this reason, any hypothesis evaluated within the simulation would not generalize to the real world; however, it is intended that the procedure of evaluation would possess some degree of transferability.

As was indicated by the example in the preceding section, this is designed to be used in a supplementary instructional capacity. It is intended to stimulate discussion and to raise questions. Because of this it has no internal evaluation to indicate to the student that his experiment is either good or bad. It does, however, provide syntax checking to insure that the statement of the design is well formed and unambiguous under the rules of the simulation.

Many of the simulations in the behavioral sciences require the student to supply a value or set of values which is digested by the model and used to produce a visible change.

By supplying several values or sets of values the student can observe the corresponding changes. Thus, as the theory goes, he discovers and becomes familiar with the principles upon which the model operates.

Researchers are currently making two observations which suggest improvement in this strategy. The first observation is that some students learn to "play the game" rather than seeking to determine the principles involved and the second, an outgrowth of the Programmed Instruction Movement, is that the real learner is the individual who initially developed the model. In view of these observations, this simulation requires the student to produce a model of a research design which is then manipulated by the system to provide experimental data. The intent here being to place the student in a situation where he can encounter and hopefully appreciate some of the problems of behavioral research.

Since this project is intended for use in the behavioral sciences where computer knowledge is not universal among students, an attempt has been made to keep the language for communicating the experiment as close as possible to the vocabulary of the researcher. Thus it should require no more than one hour to introduce the simulation to a typical class of graduate students. Once introduced to the language, the student should find it quite flexible and should be capable of expressing a wide variety of designs, with the restrictions that the number of groups and number of subjects do not exceed capacity and that the group memberships be unique and equal in number.

The instructor has the responsibility for generating the experimental environment. He must supply information such as the total number of subjects, the number of dimensions of the stimulus and the number of recognized levels within each dimension. He also must indicate the validity jeopardizing factors which are to be active during the experiment and may establish a cost for grouping, testing, and treatment.

If an instructor is not satisfied with the performance of the models he can make numerous, relatively minor internal program changes which will alter their behavior. To facilitate changes, the simulation is modular in design and is written in Fortran IV which is a universally used, practically machine independent, programming language.

C. Functional Aspects

1. Generation of the environment

Two separate programs are involved in this simulation. The first is used by the instructor to generate the environment which is placed in intermediate storage. The second retrieves the environment supplied by the first and carries out the experiment. It is the second program which communicates with the student.

Input to the first, or environment generation program as it will be called, is from one to four punched cards. The first card is essential and must contain the following information: (a) the number of models to be generated, (b) the number of stimuli of each type to be used to precondition the models, (c) the number of replications of an arbitrarily selected stimulus to be used in modifying each model, (d) intervals about the group means which determine subject-group compatibility during experimentation, (e) the maximum level of each dimension of the stimulus, and (f) the state (on or off) of the validity jeopardizing factors. The other three cards are optional and will be accepted in any order. They contain the experimental costs, the groups which are to be affected by selection-maturation interaction, and the groups which are to be affected by experimental arrangement reaction.

The current version of the program will generate up to 130 models. The generation process results in the creation of 16 parameters and one preconditioned four-cell memory for each model. The parameters are used in computing the model's reaction to a stimulus while the memory records the cumulative effect.

When a model experiences a stimulus the reaction formed is used to modify the contents of memory. The extent of this modification depends upon the number of experiences which have been previously encountered. During the generation phase each model is subjected to a specified number of every type of stimulus. If this number is small, the model will be greatly influenced by future stimuli and if it is large, the model will be made relatively immune to treatment. Through this number the instructor can indirectly preset the optimum duration of an experiment by determining the number of stimuli necessary to produce a significant change.

If the generation stopped at this point the models would be at an equilibrium with respect to their parameters and the spectrum of stimuli. Hence, a slightly favorable stimulus would "improve" the model and a slightly unfavorable one would decrease the values contained in the cells of its memory. In order to simulate a variety of student backgrounds, each model is subjected to an instructor specified number of a randomly chosen stimulus type. If this number is relatively large the variance between the models will be greater and the results of a treatment less predictable.

One of the factors affecting a model's reaction to treatment is the conformity of the model's characteristics to the average characteristics of the group in which it is placed. Instructor supplied intervals about group means are used to convert this subject-group conformity to a compatibility or homogeneity factor. A model which has characteristics several units beyond or below the group mean is assumed to be uncomfortable as a group member, hence possesses an unfavorable compatibility factor. Such discomfort is reflected in negative performance.

As was previously indicated a reaction is computed from the characteristics of the stimulus received. This version of the program is prepared to utilize only three dimensions of the stimulus; however, it could be modified to recognize as many as six dimensions by revising the EFFECT subroutine described in the next two chapters. The number of levels of each stimulus may vary from two to nine. The product of all levels and the number of stimuli of each type used to condition the memory are added to the number of replications of the randomly chosen stimulus to obtain the model's initial experience. In order to prevent an extremely sluggish model, large level values should be accompanied by a relatively small condition number. The ideal setting for these values will logically vary from one research assignment to another, thus no formula is provided. As a guideline, the reader is referred to the example provided in Appendix B.

Requiring the instructor to set the validity jeopardizing factors switches at generation time is a compromise decision. It is realized that once a system is generated several projects might be assigned, each of which would logically require a different set of factors. On the other hand it is desired that the environment be totally established at this time in order that the student be sheltered from all environmental control decisions. If the instructor wishes he can establish several environments and specify which one is to be associated with each project. If desired, these environments will differ only in the setting of the validity jeopardizing factor switches.

In most instances the fact that a switch is "on" means that the associated validity jeopardizing factor is at liberty to affect all groups. For two of the factors, however, the selection-maturation interaction and the experimental arrangement reaction, the affected groups can be externally selected via data cards. This would probably be used only when the subjects are preassigned to groups by the instructor. Group selection can be made for any factor by modifying the elements of the IGS table (see Appendix C) within the generation program. The capability for modifying this table, for any factor, via input cards would not be difficult to implement, but the need for this is not apparent.

Parameters used to determine the cost of the experiment must be defined by the instructor at generation time. These parameters are the costs to administer a test and a treatment to each student, the administrative cost required to support each experimental group, and the cost of obtaining each participant for the experiment. The participant cost is assessed only once no matter how many times the subject is tested, treated, or grouped. The group cost is assessed each time a group is formed or reformed, and the test and stimulus fees are assessed each time a participant is involved in one of these activities. Failure to define these parameters will cause them to be set to zero and no experimental cost will be reported.

If the input cards for this program are unambiguous the output should consist of a file written in internal code on disk storage where it can be retrieved by the second program. In addition a printed description of the environment is provided for the instructor. If errors are found in the input, the program continues checking the remainder of the input cards but does not attempt to create the environment. In this event the instructor receives messages which should assist in diagnosing the error.

2. Execution of the experiment

The primary purpose of this program is to interpretatively execute an experiment supplied by the student. In communicating his experiment the student must employ an ordered set of statements which are punched into cards to serve as input to the program. A general description of the available statements is included below while the detailed format is deferred to Appendix A. These statements serve eight purposes: (a) to identify the experimenter, (b) to inform the program of the number of groups to be used and the number of subjects in a group, (c) to establish group membership, (d) to shuffle or redefine group membership, (e) to specify that a group be given a treatment, (f) to specify testing for a group, (g) to request t-test statistics for two groups, and (h) to terminate the experiment. A statement is identified by the keyword contained in the initial four columns of the input card.

The order in which the statements are arranged has double significance. The interpreter expects to find the experimenter identified by the first statement encountered and the number of groups as well as the number of subjects per group by the second. The last statement should terminate the experiment. Constraints are not placed by the program on the order of the intervening statements. Since they are executed in the order in which they are received, their order is dictated by the logic of the experimental design. For example, if it is intended that one group of hand picked subjects should receive a treatment which is to be followed by an evaluation; the grouping, treatment, and testing statements must be placed in that order. If a pretest is desired, an additional testing should be requested after the grouping and before the treatment.

The identification of the experimenter is relatively straight forward from the student's point of view. The program simply takes the name supplied and uses it for identifying the printed experimental results. To the instructor, this function can be much more useful. If the first four characters of the name supplied are "INST" the program looks in columns 73-76 for the word "OFF." If found, all of the validity jeopardizing switches contained in the environment will be turned off. By turning off these switches an instructor can obtain a "true" test of the hypothesis.

Information concerning the maximum number of groups and the number of subjects per group is not given top priority but serves as a guideline or default in the absence of other data. This information is checked to insure that the maximum number of subjects available is not exceeded and the number of groups does not exceed twelve. In case no grouping statement is received prior to a test or stimulus request, groups are randomly selected on the basis of these specifications. If the explicit grouping option is used and the number of groups requested is in excess of the designated number but less than twelve, these requests will be processed providing a sufficient number of subjects are unassigned, hence can be used to fulfill the request. If explicit grouping is not specified the subjects are assigned in numerical order to the groups and the groups are numbered similarly. For example, if the number of subjects per group was to be 25 and five groups were requested, group one would consist of subjects 1 through 25, group two subjects 26 through 50, etc.

If the experimenter wishes, he may use the grouping statement to explicitly specify the group membership. In so doing it is necessary to list every subject that is a member of the designated group. In this case the group identification number may be any two digit integer. Care must be taken to prevent a subject from being associated with two groups since the program requires unique group membership lists. Partially because of this restriction and partially to facilitate housekeeping within the program an explicit group request, which is received after a test or treatment request has been processed, will erase all group membership lists and commence the redefining process. An experimenter must be cognizant of this and avoid the trap of attempting to explicitly redefine some groups, while intending to retain the membership of others, after the experiment has begun. Thus, if one group is to be explicitly redefined, all groups must be redefined even though their membership remains unchanged.

To redefine selected groups during an experiment, a regrouping statement is provided. This function enables the experimenter to shuffle and randomly reassign the subjects to groups or to randomly redefine a group from a combination of its original members and all unassigned subjects. If groups which were not previously defined are used as arguments of this function, they will be assigned a randomly selected membership provided group and subject limits are not exceeded.

Treatment requests contain the characteristics of the stimulus, the number of replications desired and the numbers of the groups which are to receive it. The characteristics of the stimulus are verified to be within the range contained in the environment. The number of replications which should be requested depends upon the conditions of the hypothesis; however, it is estimated that ten is a reasonable first approximation. Excessive replications require unnecessary execution time, while too few fail to produce a modification of the models.

A test request should contain the identification number of the group or groups to be tested and an indication of whether a pretest or posttest is to be administered. Testing in both cases consists of extracting the values, (excluding stimulus count) from the memories of every member of the group and computing the group means and sums of squares. For a posttest the average change from the previous test is obtained for each subject and is averaged for the group. The sums of squares is also computed in this case. If a posttest is requested in a case where a pretest has not been given, a warning message is printed and a pretest is performed. Test results accompany any subject which is transferred from one group to another. Test results are stored for each subject until three tests have been requested for his group, the group is redefined, or the experiment is terminated. At such time the test results are printed collectively by group. Failure to specify the groups to be tested or treated, results in the function being performed on all groups which have been defined.

Requesting a t-test requires the identification of the groups being compared. Such a request results in the computation of a pooled variance t-test statistic from the most recently administered test, and where applicable from the change in the previous test scores. A separate statistic will be computed in each case for each of the three cells of memory which record the cumulative effect of encountered stimuli.

The experiment termination function causes any lingering test scores to be printed and produces a fresh copy of the original environment to be used for the next experiment. Because of this, student experiments can be "batched" with each student using the same subjects under the same conditions. In this aspect the simulation differs greatly from the real world where experimental effects are cumulative and it is never possible to reproduce an environment exactly as it was prior to experimentation.

A concerted effort has been made to provide the user with an adequate amount of meaningful information in an understandable, compact form. The primary output of a well defined experiment includes the average test scores and differences, and the requested t-test statistics. In addition, in order to provide a history of the experimental process, a notation is made each time a requested function is performed. To assist in diagnosing possible errors, any irregularities in the input are also noted. Due to their volume, individual test scores are printed only upon special request by the experimenter.

D. Requirements

An IBM System 360 Model 65 was used to develop this simulation. The programs were written in the Fortran IV language and compiled and executed by the WATFIV (Waterloo Fortran) System. Under this system, the environmental generation for 130 models required 128,000 bytes of main memory in which to compile and execute, with compile time being 1.01 seconds and execution time 19.88 seconds. The experiment shown in Appendix B required 192,000 bytes of main memory with compile and execute times being 2.95 and 12.15 seconds. For interprogram communication 9,768 bytes of secondary storage is required.

IV. DESCRIPTION OF THE COMPUTER PROGRAMS

A. Introduction

Before discussing the computer programs it is necessary to define the terms program and routine as they pertain to this project. A program is a collection of instructions which directs the computer in a step by step manner to perform a given job. The job may be a comparatively simple one such as averaging a set of numbers or may be quite complex such as scheduling the classes for a large university. The act of analyzing the problem area and defining it as a step by step process which can be incorporated into a computer program is called systems analysis. If the job is not simple it is customarily subdivided into tasks each of which consists of a portion of the problem which can be logically and functionally isolated from the others. The computer program which performs the operations necessary to complete a task is called a routine. If the routine is envoked by another routine within the same problem it is termed a subroutine. Thus a program and a routine are both composed of computer instructions, the distinction being that the routine is structurally a subset of and logically subordinate to a program. The Fortran names assigned to the subroutines will be used throughout this discussion.

The motivation for utilizing a hierarchial structure in this simulation is simplification and economy. By isolating

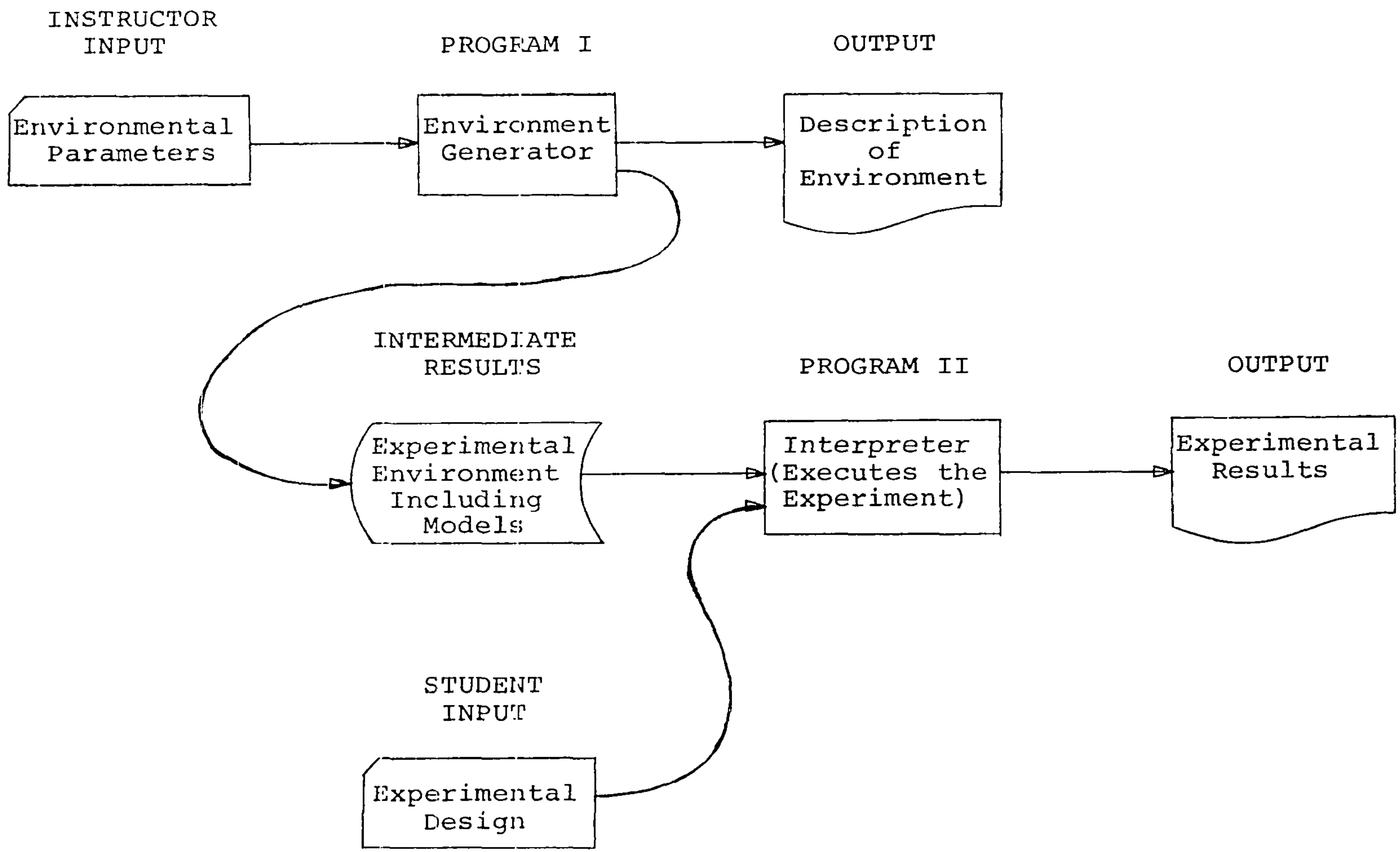

Figure 1. Diagram of the simulation

the tasks involved, the performance of the simulation is much more easily understood. In addition, locating program errors and making modifications are facilitated. Since the Fortran statements must be translated by the computer into its own language prior to executing the program, a savings could be realized by retaining the translated statements. Each time a modification is necessary which affects only one or two routines, only the affected routines need be retranslated. Since each task performs a function which can be isolated, the supporting routine frequently can be constructed and perfected independently, resulting in an additional saving of computer time.

An overview of the computer programs was presented in Chapter Three in order to enhance the reader's understanding of the functional aspects of the simulation. In this chapter a more detailed description of the program structure and organization will be presented for both the environment generation program and the interpreter. Since these programs perform independently the remainder of the chapter has been organized into two sections, one for the discussion of each program. Figure 1 shows the relationship between these programs, the student and instructor input, and the experimental results.

B. Environment Generation Program

This program consists of a main routine and four subroutines, the relationships of which are shown by Figure 2. The main routine serves as an administrator, communicating the requests of the instructor to the subroutines MEMGEN, MODFY, and PARGEN; directing and coordinating their responsibilities in establishing the environment. The subroutine MEMGEN interacts with a lower level subroutine called EFFECT.

I Main Routine
- II MEMGEN
  - III EFFECT
- II MODFY
- II PARGEN

Figure 2. Structure of the environment generation program

Upon reading the description of the environment which is supplied by the instructor, the main routine makes several accuracy checks and computes auxiliary values. It first verifies that the maximum level of at least one dimension of the stimulus was supplied and computes the number of dimensions as well as the number of types of stimuli which can be encountered. It resets any validity jeopardizing factor switches which do not conform to the instructor's specifications and insures that a positive number of models is to be generated. If cost information is entered it is simply transferred to storage for future use. Information involving group selection for experimental arrangement reaction and selection-maturation interaction is given along with program control to the MODFY subroutine where it is processed. If no errors are detected in the input data, the main routine transfers control to PARGEN for the generation of the model's parameters and then to MEMGEN for generation and refinement of the model's memory. Following successful completion of MEMGEN, the description of the environment is printed and the environment is written on secondary storage.

One of the constituents of the environment is a table called IGS. The rows of this table correspond to the 12 possible groups of the experiment, and the columns represent its various stages. These stages being: after the groups have been formed, before a test is given, after a test is given, before a stimulus is applied, and after the stimulus has been received. The entries in the table are the validity jeopardizing factors to which each group is subjected at each stage of the experiment. Modification of the entries in this table is the primary purpose of the MODFY subroutine.

This modification is basically straight forward. Since the groups to be affected by the factor are listed on the input card and since the single column of the table which contains the factor is assumed to be known by the routine, the process consists of insuring that the factor is present in the column for the specified groups and absent for the others. It is slightly complicated, however, by an effort to conserve space. Since a computer word is capable of storing approximately ten digits and only nine validity jeopardizing factors need be stored in this table, all applicable factors are stored in each cell. This is done by packing the identification numbers of the factors into separate digits of the cell. Thus a value of 56 would indicate that the associated group should be subjected to validity jeopardizing factors 5 and 6 at the stage of the experiment designated by its column number. The process of cell modification involves packing and unpacking these values. In addition a check is made to insure that the group numbers on the input card fall within the range from one to twelve.

Parameters for all models are maintained in the SP table where sixteen consecutive entries are assigned to each model. A description of the parameters is given in Table 1. From this table it is seen that a reference to parameters includes what might be descriptively termed temporary memory. In either case, the values are randomly generated and uniformly transformed to the acceptable range for each. Generation and assignment of these values is the sole function of the subroutine PARGEN. Once established the model's parameters are

Table 1. List of parameters and temporary memory

Parameter number	Description	Range
1	IQ	60-140
2	Sensitivity to previous success	0-.5
3	Ability to generalize	0-.5
4	Sex	0, 1
5	Significance of current mood on peer attitude	0-1
6	Significance of peer attitude on course attitude	0-1
7	Significance of teacher concept on learning	0-1
8	Significance of teacher concept on peer attitude	0-1
9	Significance of current mood on course attitude	0-1
10	Significance of teacher concept on course attitude	0-1
11	Previous change in learning rate	-1-1
12	Previous attitude toward the group	0-100
13	Previous attitude toward the course	0-100
14	Previous learning rate	0-100
15	Random number to be used in generating the memory	a
16	Student's group compatibility factor	0-1

[a]The value of this parameter corresponds to one of the valid stimulus types, hence is dependent upon the environment.

used to generate its memory.

A four cell memory for each model is stored in the SUMEFF table. The first cell records the number of stimuli which the model has encountered and the last three their cumulative effect. For this implementation these cells are intended to represent learning rate, attitude towards its course of study, and attitude toward the experimental group in which the model is placed. These variables may assume any real value between zero and one hundred, with one hundred being high or favorable. Fifty is considered to be average. Precise definitions of these terms will be dependent upon the research project which is assigned by the instructor. However, attitude toward the course of study and attitude toward the group are intended to have their normal real world interpretation.

Learning rate may be defined to be 100 times the model's actual achievement divided by its maximum potential. In the real world, for example, a student who under the most favorable conditions could answer ten questions of a test correctly and who answered only five could be considered to have learned at a rate of 50. In this case reliable determination of a student's potential would pose some severe difficulties; however, in the model the actual computation of this value simply short circuits the problem. The computation of an instantaneous learning rate, course attitude, and group attitude in reaction to a stimulus is the responsibility of the subroutine

EFFECT. These quantities result from the evaluation of three equations whose independent variables include the model's parameters and previous attitudes, characteristics of the environment, and the stimulus. The actual equations used in this implementation are explained in Chapter Five. EFFECT is the only subroutine which is used in both programs.

The initial memory of each model is created by the subroutine MEMGEN. This is done by setting the count cell to zero, each of the effects to 50 and then subjecting the model to stimuli. A stimulus is formed and transferred along with the model's parameters and memory to the EFFECT subroutine where the reactions are computed. A multiple of these reactions is averaged with the contents of memory to form its new values. This process is repeated for every type of stimulus for each model generated. If the instructor specified a modification factor, the memory of each model is then skewed by subjecting the model to a random stimulus which is formed from one of the model's parameters.

C. Interpreter

The structure of the interpreter is shown in Figure 3. It consists of a main routine which communicates with seven first level subroutines. These are called COMP, GROUP, GRPAVE, HOMO, OUTPT, STIM, and TEST. Subroutines GROUP, STIM, and TEST each envoke two of the three second level subroutines called OUTPT, VJF, and EFFECT. The subroutine EFFECT was

```
I  MAIN
     II  COMP
     II  GROUP
          III  OUTPT
          III  VJF
     II  GRPAVE
     II  HOMO
     II  OUTPT
     II  STIM
          III  EFFECT
          III  VJF
     II  TEST
          III  OUTPT
          III  VJF
```

Figure 3. Structure of the interpreter

described briefly in the preceding section, the others will be described here.

Prior to exploring each subroutine, the global view of their interaction may be seen by observing the rough correspondence between these subroutines and the purposes served by the input statements listed in Section C-2 of Chapter Three. Since the amount of work required is relatively minor, the main routine processes the identification of the experimenter, the group number and size specifications, and terminates the experiment. Subroutine GROUP establishes and intermixes group membership. STIM administers the treatments; and TEST, as one may suspect, administers all tests. The duties of subroutine COMP include the calculation of the test statistics.

The remaining routines perform auxiliary functions which support the experiment. OUTPT computes averages and prints the results of test scores. VJF enacts the simulated validity jeopardizing factors while GRPAVE computes some average characteristics of each group. Subroutine HOMO uses these averages in determining the relative homogeneity of the group and the resulting compatibility factor for each member.

The main routine supplies the environment for the experiment and receives all communications from the experimenter. As each new experiment is encountered the environment is recalled from secondary storage where it was left by the environment generation program. Once the program is operating, the receipt of a termination statement for one experiment followed by the identification of the experimenter for the next initiates this process. Because of this, all experiments are conducted in an identical setting regardless of the number of predecessors.

The first card of any experiment must be the identification statement. If this is not the case, all statements will be skipped until an identification statement is encountered or the input stream is exhausted. On recognition an identification statement is checked to determine if it belongs to an instructor and if so, to assess the proper status to the validity jeopardizing factor switches. Once an identification statement has been processed, all valid statements which precede a termination statement are recognized and delivered to the appropriate subroutine where they are immediately executed. Recognition of a termination statement causes the cost factor associated with procuring subjects to be computed and all test scores which remain in storage to be printed. The total cost of the experiment is printed and then the input stream is checked for another experiment.

The main routine also keeps a record of the status of the experiment with respect to the formation of the groups. If a test or treatment request is received prior to a grouping request, the control must be transferred to subroutine GROUP in order that group memberships can be established. If an explicit grouping request is received after a test or treatment has been processed, this information must also be passed to the subroutine GROUP to insure that any test scores which remain in storage are printed prior to group redefinition. In addition, it is necessary to recognize newly formed groups in order that averages and subject-group compatibility factors can be formed.

The GROUP subroutine consists of a logically distinct section to process each of the three types of grouping requirements. One section systematically assigns subjects to every group in the experiment, another executes membership assignments made by the experimenter, and a third randomly defines or redefines the groups. While these sections are quite different they perform several common acts. Each increments the cost of the experiment associated with group formation, zeroes the test count, and invokes the VJF subroutine for newly formed groups. Error and warning messages are universally printed where limits may be exceeded or rules violated. Finally, an affiliation array is maintained to designate the group to which each model belongs. As an assignment is made, the number of the recipient group is stored in the element of the array which is associated with the model assigned.

At the beginning of an experiment, in absence of any explicit specifications, the routine will utilize information contained in the design statement to form the groups. In this case, models are assigned consecutively until the membership quota for each is met. The groups are identified with consecutive integers beginning with 1 and not exceeding 12. Since the parameters and memory of the models are randomly generated, this procedure should produce equivalent partitioning of the sample population.

Explicit grouping statements contain an identification number which is specified by the user. This presents somewhat of a problem since it is advantageous within the routine to use the actual group numbers to index the various quantities which are associated with each. The maximum convenience is attained when the defined groups are identified by consecutive integers beginning with 1. For this reason the experimenter's identification numbers are placed in an array as the groups are defined and the index of the array is used to internally identify each. On output the inverse transformation is made. In addition to converting these numbers, the section of the routine which handles explicit requests must identify the models with the specified groups and check to insure that no member is multi-affiliated. If the number of elements in any membership list exceeds the design specifications, the list is truncated with the excess being ignored.

If groups are to be defined or redefined it is necessary to discover if an intergroup mix is being requested or if the reassignment is to be made from a combination of the original members and all unassigned models. If the latter is the case the numbers of all unassigned models are placed in an array. In either case the designated groups are dismembered with each member being relieved of its affiliation and its number being placed in the array. The elements of the array are then mixed by interchanging each with one of the other elements chosen at random and assignment or reassignment is made to the groups from the shuffled array.

When new associations are formed, new collective averages must be computed. This is done for all groups regardless of whether they are new or residual and is the function of the subroutine GRPAVE. The averages computed are learning rate, attitude toward the course of study, and IQ. In addition the number of male members is tallied. These values are stored immediately following the membership list in an array called IGROPS.

The averages are used by the subroutine HOMO to assess a subject-group compatibility factor for each of the members of the group. To do this it is necessary to determine the number of units that a subject's IQ, learning rate, and course attitude differs from the group averages, where a unit is defined by the instructor for each measure and carried in the environment. Each of these deviations as well as the ratio of the sex of the subject to the predominate sex of the group is converted to a value between 2 and -4 by a table look-up procedure. Negative values are intended to depict an unfavorable subject-group relationship. The compatibility factor attributed to the subject results from transforming the sum of these values into the range from 0 to 1 such that a value of 0 maps into .5. This factor is stored as the last parameter of the model.

A treatment request is referred by the main routine to the STIM subroutine which serves primarily as a communications center invoking subroutines VJF and EFFECT to perform the major duties. Upon receipt of a request, STIM isolates the characteristics of the stimulus and converts the identification numbers of the recipient groups to internal notation. Then each member of each group is subjected to prestimulus validity jeopardizing factors, the stimulus, and poststimulus validity jeopardizing factors for the number of replications requested. When all groups have been processed, a statement of the accomplishment is printed.

The reaction to the stimulus is incorporated into the subject's memory by adding each of the components of the reaction to the product of the appropriate memory cell and the number of previous stimuli experienced by the model, and dividing this sum by one more than the number of previous stimuli. The resulting values replace those in memory. From this discussion it can be seen that subjects with relatively few previous experiences are influenced to a greater degree by a stimulus than are comparable models with vast experience. This fact can be used to control the effect of the experiment and to demonstrate a form of experimental fatigue.

Performance evaluation is accomplished by saving the values of the memory for each member of a group. This is the duty of subroutine TEST and is in itself quite simple. However, the housekeeping chores, necessitated by the provision for transferring group affiliation, and communication with the output subroutine complicate the process.

As was affirmed earlier, there are three cells of a subject's memory which are saved as a result of testing. Since an experiment typically requires two or more tests to be given to each group, it would not be economical of time nor space to print each subject's scores after every test. For this reason, the results are saved in the TSCORE matrix until three tests have been completed or the group is disbanded. Entries are made in this matrix by individual instead of by group, and the number of entries for each individual, modulus 3, is kept in the array LTS. From this it is possible to locate the previous test scores for any subject, providing a previous test has been administered, and to record the pretest-posttest change. Care is taken to prevent a previous set of scores, for a recently acquired member, from being overwritten by the current test results.

In TEST as in STIM the group numbers are converted to internal notation and the validity jeopardizing factors are activated before and after a group has been tested. During the testing process the routine transfers the values from the memories of each individual to the proper location in the TSCORE matrix, concurrently forming the sum of the squared deviations from the mean and where applicable the sum of the squared deviations from the mean pretest-posttest change. In the event that the test is the third received by the group since its formation or since previous output, control is passed to the subroutine OUTPT which prints all of its accumulated scores. The terminal activity of TEST is to notify the experimenter of the groups which were evaluated.

Subroutine OUTPT may be called by the main routine or by TEST. In either case it prints all statistics for a particular group along with identifying information. If individual scores are requested they are each printed on a separate line. The line may contain 3, 6, or 9 scores depending upon whether the individual has received 1, 2, or 3 tests. The average scores for the group are printed followed by the sums of squared deviations from the means, the average change from the previous test, and then the sum of squared deviations from the group's mean changes. Any values associated with the change which could not be computed or were not requested are given the value -1.0.

Since the OUTPT routine is called when needed, the group statistics may appear between the statements of experimental progress on the output forms. If this proves to be confusing to the experimenter, the routine can be modified to store the group statistics on intermediate storage for the duration of the experiment, at which time they could be recalled and printed.

The COMP subroutine was added to the simulation in order to reduce the busy work associated with identifying significant differences. It extracts the means and accompanying deviations from the tables which are filled by the subroutine test and computes pooled variance t-test statistics from the most recent test results for two designated groups. If both groups have taken two or more tests, statistics are also computed from the change in scores between the two most recent ones. The computed values, or an excuse for not computing the values, are printed upon completion of the calculations. Because this function is interpretative and since the results of testing are stored, the comparisons may appear in the output prior to the actual test results.

The last subroutine to be discussed is VJF. Since its purpose is to simulate the action of the real world validity jeopardizing factors it is considered to be the most significant contributor to any fidelity the simulation may possess and consequently the most difficult to perfect. For this reason the numerous decisions to be made throughout this routine have been incorporated in a set of tables and arrays which can be easily modified when experience indicates the need and manner for so doing. The decisions contained in tables are: (1) whether a factor is to be active during the experiment, (2) at what stage of the experiment an active factor is to be applied, (3) the groups which are to be affected by each factor, (4) the influences a factor should have, (5) the magnitude of these influences, and (6) the maximum number of times a factor may be invoked for each group. With the exception of the factors to be activated and in two instances the groups to be affected by a factor, modification to these tables requires a program change. To facilitate such a change, the implementation values and a description of the tables are included in Appendix C.

The unit of invocation for VJF, like most of the other routines, is a group with the operations being performed on the members. On entry the routine selects a value from the appropriate cell of the IGS table which was described in Section B of this chapter. This entry contains the factors which are to be applied. If the cell is empty control is returned to the calling program, if not the factors are unpacked for consecutive processing. A check is then made to determine if the switch for a factor is turned off or if the group has endured the maximum number of encounters. If either is the case the factor is removed from the IGS table in order to halt the action earlier on future occasions, and the processing of the factor is considered to be completed. If the factor escapes these traps the objects of its wrath are identified and in most cases the magnitude of the effect is determined. The factor is then applied to each member of the group.

Typically, the validity jeopardizing factors affect the subject's parameters or memory values by increasing or decreasing them by a given percentage and insuring that they remain within limits. The exceptions to the above procedure are experimental mortality and statistical regression. In the case of experimental mortality randomly selected subjects are removed from the experiment by storing a code in the LTS table. For statistical regression the memory values of high and low individuals are lowered and raised respectively.

Of the tables in this routine only IGS can be externally modified and for this reason it is the only one included in the environment. If the need should arise it would not be difficult to equip the others in a similar manner.

Because VJF is called frequently during the interpreting of an experiment, the time and consequently the cost of executing the simulation is increased substantially by the number of active validity jeopardizing factors. In addition, the difference between the influences of several of the factors may well be too subtle to measure within the confines of the population available. For these reasons it is suggested that an instructor choose with some discretion the number of factors activated.

V. DESCRIPTION OF THE MODEL

In prior chapters the simulation has been viewed from the external and administrative vantage points. Its input requirements and output results have been described along with the functions performed by each of the programs and their supporting subroutines. In this chapter the focal point is the model, providing an internal perspective of the operation

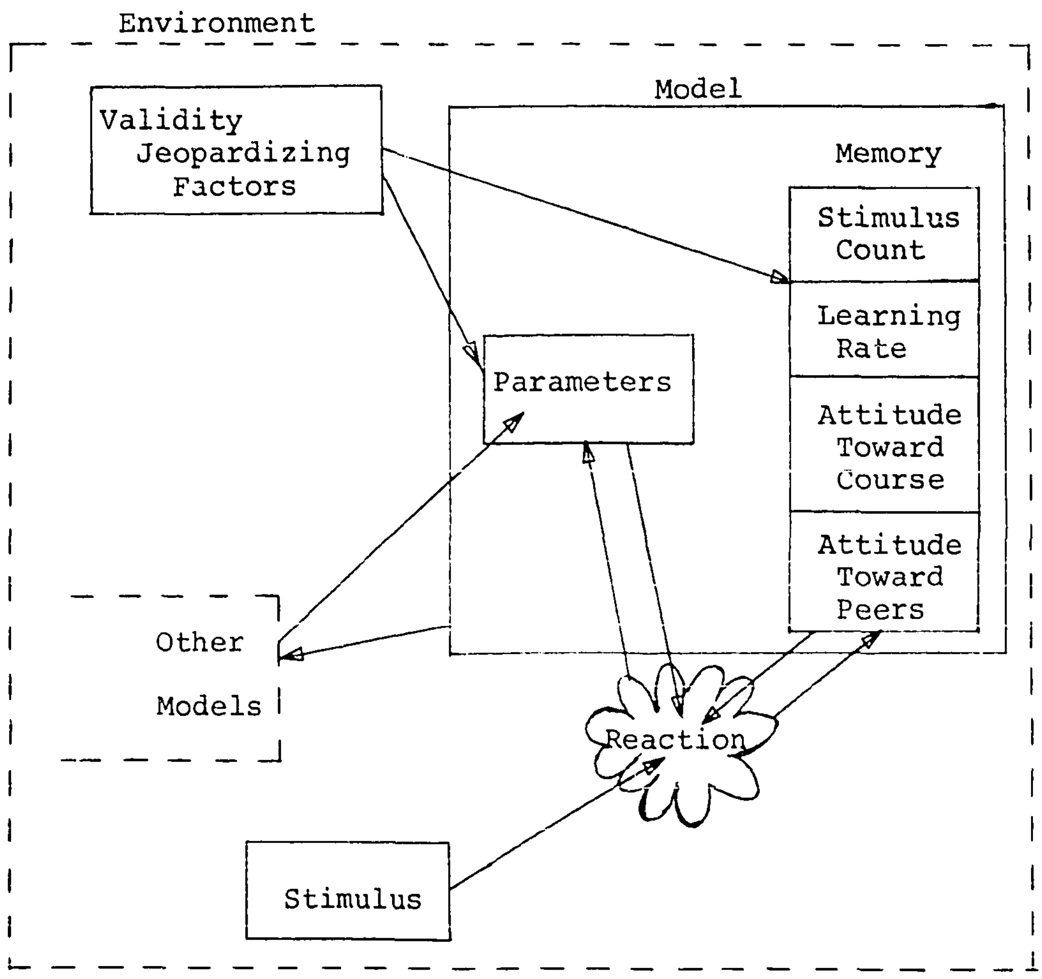

Figure 4. Components and effects of a model's reaction to stimuli

of the simulation. The relationships among the elements of the model, its environment, the validity jeopardizing factors, and the stimulus are explained. Figure 4 shows the relationships from this view.

A. Reaction to Stimuli

The fundamental activity of a model is its reaction to a stimulus. Every reaction consists of three parts corresponding to the three non-numerational segments of memory which record learning rate, course attitude, and peer attitude. Each part is formed from characteristics of the stimulus and segments of the model's history. The relative contribution of these factors is determined by a model's parameters acting through an arbitrary set of formulas which are discussed later in this section. The parameters are shown in Table 1.

In order to simplify the discussion, mnemonic abbreviations have been adopted for the model's parameters and memory elements as well as the characteristics of the stimulus. These abbreviations along with their identification, range, and the components of the reaction which are dependent upon them are shown in Table 2. The first 16 entries in this table should be recognized as the model's parameters, thus their abbreviation commences with the letter P. This logic is extended to the stimulus or treatment characteristics where the initial character is a T. With the elements of memory, however, it is necessary to deviate from this scheme if the

Table 2. Abbreviations of variables used in computing reaction to stimulus

Mnemonic	Variable identification	Range	Use[a]
PIQ	IQ	60-140	C1
PPS	Previous success	0-.5	C2
PGEN	Ability to generalize	0-.5	C1, C2, C3
PSEX	Sex	0,1	C3[b]
PMPA	Mood (peer attitude)	0-1	C3
PPACA	Peer attitude	0-1	C2
PTL	Teacher (learning)	0-1	C1
PTPA	Teacher (peer attitude)	0-1	C3
PMCA	Mood (course attitude)	0-1	C2
PTCA	Teacher (course attitude)	0-1	C2
PCLR	Learning rate change	-1-1	C2
PGA	Group attitude	0-100	C2, C3[b]
PCA	Course attitude	0-100	C2, C3[b]
PLR	Learning rate	0-100	C2
(unused)	Random number		
PC	Group compatibility	0-1	C3
XMLR	Learning rate (memory)	0-100	C1
XMCA	Course attitude (memory)	0-100	C2
XMPA	Peer attitude (memory)	0-100	C3
TTP	Teacher's personality	1,2,3	C1, C3
TTAR	Teacher's academic record	1,2,3,4	C1
TTCA	Teacher's course attitude	1,2,3	C2
PM	Previous mood ½(PGA & PCA)	0-100	C2, C3

[a]Entries in this column are the components of the reaction which the parameter directly influences.

C1 is learning rate.
C2 is course attitude.
C3 is peer attitude.

[b]Denotes indirect influence.

mnemonics are to be used as variable names in the Fortran program. Fortran variables commencing with the letter M are recognized as integers instead of real or decimal variables. For this reason an XM is used.

The components of the reaction are C1, C2, and C3 which respectively identify learning rate, course attitude, and peer attitude. Throughout the text other abbreviations are parenthetically isolated immediately following the initial encounter of their long form.

Each portion of the reaction is considered separately; however, because the stimulus is common to the three computations, its preprocessing is exposed here. Since the resultant values, that is the updated elements of memory, must be no less than zero and no greater than 100, it is convenient to restrict the components of the reaction to this range. Furthermore, it is convenient to similarly transform the ingredients of the reaction, one of which is the stimulus. The characteristics of the stimulus enter the computation as digits. Since the maximum value of each characteristic is known, the entering digits can be linearly transformed into the desired range. Under this mapping a midrange characteristic receives the value of 50.

1. Attitude toward peers

On receiving a stimulus, the model's instantaneous peer attitude is computed from the subject's group compatibility factor, the teacher's personality, and the mood of the subject prior to this encounter. The compatibility factor is the output of subroutine HOMO and is stored as the subject's last parameter. The teacher's personality is the first dimension of the stimulus, and the subject's mood is obtained by averaging the two elements of the parameter list recording peer and course attitude from the preceding reaction. This component of the reaction is then tempered by the model's previous experience to produce the peer attitude value. The equations are:

Instantaneous reaction (IR) =

$$\frac{PC\times 100 + TTP\times PTPA + PM\times PMPA}{1 + PTPA + PMPA}$$

$$C3 = IR\times(1-PGEN) + XMPA\times PGEN.$$

The effect of dividing by the sum of the parameters in computing the instantaneous reaction is to insure that the resulting value lies within the desired range. This has the effect of attributing a percentage of the reaction to each of the three components. For example, teacher personality composes $\frac{PTPA}{1 + PTPA + PMPA} \times 100$ percent of the reaction. Since the parametric values used are always greater than or equal to zero, the resulting value will be no larger than the largest contributing factor and no smaller than zero. This technique is generously used throughout these computations.

2. <u>Attitude toward course of study</u>

Like peer attitude, attitude toward the course of study is computed in two stages. In this case, a partial attitude (PA) is determined from the teacher's attitude toward the course he is teaching, and the model's peer attitude, previous mood, and previous experiences. Already it can be seen that peer attitude and course attitude are not independent. They do differ, however, since the teacher characteristic used here is the third dimension of the stimulus and the reference to previous experiences includes only course attitudes. The correlation is further decreased by the second step of the calculation.

In this step a linear fractional transformation is used to modify the partial attitude by the previous change in achievement. If the subject's recent achievement has increased, his partial attitude is increased, while if the level of achievement has dropped the partial attitude is decreased. The resulting value becomes the course attitude. These relationships are expressed in the following equations.

$$PA = \frac{(TTCA \times PMCA + C3 \times PPACA + PM \times PTCA + XMCA \times PGEN) \times 100}{(PMCA + PPACA + PTCA + PGEN)}$$

$$C2 = \left(\frac{PA \times (PCLR + 1) \times PPS}{(2 \times PA - 1) \times PCLR + 1} + PA \times (1 - PPS)\right) \times 100$$

3. Learning rate

Since the model's learning rate is heavily dependent upon PIQ, the IQ parameter, the computation is done in three steps in order to show this influence. Initially, a partial learning rate (LR) is formed from the teacher's academic record, the model's attitude, and the previous learning experiences. In this equation, IQ is used to determine the influence of previous experience such that a model having an above average IQ will be more heavily influenced.

$$LR = \frac{C2\times\frac{1}{2} + TTAR\times PTL + XMLR\times PGEN\times\frac{PIQ}{100}}{\frac{1}{2} + PTL + PGEN\times\frac{PIQ}{100}}$$

An auxiliary factor (AF) is computed to relate the contribution of the teacher's personality to the cognitive aspect of the reaction. In this case a low personality having a scale factor of 1, is detrimental to learning while a favorable personality has a positive effect. The magnitude of this effect is more significant for models having a low IQ. This relationship is determined by:

$$AF = \frac{\text{TTP - Average Personality}}{\text{Maximum Value of the Numerator}} \times \frac{\text{Maximum IQ - PIQ}}{80}$$

The partial learning rate is within the range from zero to one hundred and the auxiliary factor ranges from -1 to +1. These quantities are combined using the same linear fractional transformation employed in determining course attitude. Here a negative auxiliary factor decreases the partial learning rate while a positive value increases it to form the learning rate component of the reaction.

$$C1 = LR\times(1 - PTL) + PTL\times\frac{LR\times(AF + 1)}{.02\times LR\times AF - AF + 1}$$

The mathematical relationships described here are not proclaimed to be truths of life. They are presented to promote understanding of the functional aspects of the simulation in order that an instructor can predict outcomes, and where desired make program modifications. These equations are the foundation for the Fortran code contained in the subroutine EFFECT.

From these equations, it can be seen that the model's parameters and memory heavily influence the computed reaction. It can also be seen that one aspect of the environment, the stimulus, makes a sizeable contribution; however, the effects of the other recognized aspects of the environment, the validity jeopardizing factors and the interrelationship among models, are obscured since they enter the computation indirectly. The intermodel relationships are constrained by group boundaries and summarized within each model. This summary is identified as the group compatibility factor, and recorded as the model's last parameter. Validity jeopardizing factors, with the exception of mortality and instrumentation, act through one or more of the model's parameters or memory elements, consequently their effects are not easily identified. These influences are discussed in the ensuing section.

B. Effects of Validity Jeopardizing Factors

The validity jeopardizing factors which are incorporated in this simulation are shown in Table 3 along with the parameters or memory elements which they modify. Like most of the decisions concerning these factors, their objects of influence are arbitrary and are included in the program in tabular form for convenience of modification. These factors constitute a

Table 3. Validity jeopardizing factors and affected parameters

Factors	Parameters and memory affected		
Maturation	PMPA	PPACA	PMCA
Experimental Arrangement	PGA	PCA	PLR
Testing Sensitivity	PIQ	PTL	
Multiple Treatment Interaction	PGEN	PPS	
Testing	XMLR		
Statistical Regression	XMLR	XMCA	XMPA
History	PGA	PCA	PLR
Selection-Maturation Interaction	PGEN	PTPA	PTCA
Experimental Mortality			
Instrumentation			

major subset of those identified and defined by Campbell and Stanley (9).

In a given experiment a factor may be either active or inactive. If active, its unit of prey is the group, within which all members indiscriminately receive the prescribed modification. This effect can be seen by the following individual analysis of the action of each factor.

Maturation, as it pertains to the real world, is a physiological, anatomical, or psychological change occurring within the individual. Examples are fatigue, physical growth, and puberty. In the simulation this could be reflected in many ways, some would show long term maturation by decreasing the effect of moods and increasing stability, while others would mirror short term effects by decreasing the power of the stimulus or altering the teacher concept. For this implementation the significance of the current mood in determining both peer attitude and course attitude and the contribution of peer attitude to course attitude are increased, thus giving the model less emotional stability.

The model's parameters, which are seen in Table 2, include the components of the previous reaction. Two of the factors, experimental arrangement and history, alter these values between the time that they are used to update memory and the time they are used in computing the next reaction. Through this approach their effect can be turned on and off during the course of an experiment. Since these "parameters" are replaced after each reaction is formed, modification of them has only a temporary effect, a characteristic which is not shared by most of the others.

Experimental arrangement is a reaction which occurs because the treatment and control groups assume different attitudes about the experiment. For example, considering it a privilege to receive the treatment can produce significant results even when the actual treatment is imaginary. By operating on the short term memory this factor can be designated for selected groups with very little residual effect on transient models.

History, which is a change attributable to external factors other than the stimulus, has similar requirements on effect longevity, especially in reference to a time series design. Time series experiments are a series of observations, two or more of which are separated by a stimulus. If a change in the model is observed to repeatedly coincide with the stimulus its significance is assumed. In this case, additional changes are produced in order to obscure any effect the stimulus may cause, thus making the experiment less conclusive. Both history and experimental arrangement are enacted by increasing the components of the reaction.

Although testing of some type is essential to experimentation, it can have two adverse effects. It can produce learning and it can sensitize the subject. Learning transpires when a subject acquires knowledge or skills, from taking a test, which alter the scores on any subsequent tests. This is simulated by increasing the value of the learning rate stored in memory. Testing sensitivity occurs when, as a result of being tested, the subject is more or less responsive to the experimental variable. This would occur, for example, when test questions are remembered and recalled during a certain type of instruction which is being used as the experimental treatment. In the simulation, this effect is produced by increasing the IQ parameter along with the influence the teacher has on learning.

Experiments in which several treatments are administered to the same individuals are subject to multiple treatment interactions. This occurs when the response to one treatment carries over to dampen or increase the response to succeeding ones. It is produced by decreasing the model's ability to generalize and increasing its sensitivity to previous success.

For certain experiments, groups may be chosen because of extreme qualities such as very high or very low IQ or superior or inferior achievement. Individuals falling into these categories are frequently heavily influenced by good or bad luck which does not repeat on subsequent tests. Thus the groups tend to regress toward the norm, apart from any effect of the stimulus. This phenomenon of statistical regression is simulated by increasing the memory values of those group members which rank very low and decreasing those which are extremely high. At present, insufficient data is available to establish the proper settings for this manipulation, hence, if the factor is active it is applied to all models having scores of three units above or below the population norms. Experience should provide a more satisfactory approach.

Another factor which affects parameters is selection-maturation interaction. In real world experiments this occurs when selected groups, because of age or other differences, are changed, as a result of time, in a manner which clouds the experimental effect. In the simulation the factor is reproduced by increasing the model's ability to generalize as well as the effect of the teacher concept on course attitude and by decreasing the effect of the teacher concept on peer attitude.

Experimental mortality and instrumentation are similar in that they do not modify the model. Instrumentation occurs when a change in the measuring device causes a variance in the measurements. Since students have no control over the actual mechanics of testing the models in this simulation, errors of this type would be difficult to isolate and consequently would probably add static to the learning process. In view of this, the facility to activate the factor has not been completely implemented; however, if it is needed it can be produced by altering the scores as they are obtained from the models.

Experimental mortality is the result of subjects quitting or being dropped from the experiment prior to its completion. Here, if the factor is active, a prescribed percentage of the models are randomly selected and removed from the experiment. Since random selection is used, this should have no predictable effect on the experimental results; however, it should raise the question of the importance of participant loss to experimentation.

The instructional strategy which the validity jeopardizing factors support has not been established. For this reason it is difficult to affix the magnitude and direction of their influence. In fact, it may be desirable to alter these influences, beyond the capability of the on-off switches, from experiment to experiment in order to produce a desired effect or to support certain educational objectives. In anticipation of this, most of the decisions affecting these factors have been incorporated in tables which can be readily replaced or modified. The tables of implementation are included in Appendix C.

C. Accuracy of Measure

One of the aspects of this simulation which may disturb a reader who is schooled in educational measurement is the precision with which the parameters are recorded. Unfortunately, measuring human psychological variables to greater than unit accuracy is generally misleading to say the least. For instance a real world IQ of 100, under favorable conditions, may mean the value lies between 99 and 101. One reason for the extended accuracy here is convenience. Since a real Fortran variable, for the computer of implementation, contains approximately seven decimal digits, decreasing the accuracy would involve assigning zeros to the low order positions. Thus, for the sake of time and effort, the reader is asked to ignore any digits he finds offensive.

What has been said concerning the accuracy of parameters also applies to components of the reaction and the memory values. However in this case, convenience is not the entire reason. Under an earlier design, the elements of memory were maintained as integer values between zero and one hundred. As a model accumulated experiences it became frozen since it was not possible to create a reaction of sufficient magnitude to modify the memory value. Under this scheme experimental fatigue was so prevalent that experiments not only revealed no significant differences, but frequently produced no observable changes. In this case, while accuracy may be asthetically objectionable it is pragmatically essential.

D. Model Response

The parameters for three models, labeled S1, S2, and S3, are shown in Table 4. The purpose for including this table of parameters is to present the reader with a profile of the individual model which should serve to facilitate the

Table 4. Initial parameter values (rounded to four decimal places)

Parameter number	Model number S1	S2	S3
1	61.9567	138.5324	102.2910
2	0.1250	0.3427	0.2117
3	0.3245	0.2948	0.3203
4	0.0000	1.0000	1.0000
5	0.7559	0.2672	0.9921
6	0.8835	0.1800	0.4657
7	0.1928	0.6228	0.2693
8	0.2507	0.5776	0.4216
9	0.1884	0.6878	0.9615
10	0.3725	0.9274	0.9010
11	-0.2829	-0.1606	-0.1711
12	48.4192	43.7998	53.2284
13	54.3650	65.6257	67.1494
14	38.9161	53.2631	54.4375
15	111.0000	213.0000	131.0000
16	0.3750	0.5625	0.9375

discussion of calculations contained in Tables 4 and 5. In order to show the significance of IQ (parameter number one), models are included which nearly span the allowable range from

60 to 140. Model S2 ranks barely above the minimum with a 61.9567, model S3 is slightly above average with 102.2910, and model S2 approaches the upper bound with 138.5324.

The first ten parameters are random values assigned by the PARGEN subroutine. Parameters 11 through 14 are temporary memory, recording learning rate change and the three components of the previous reaction. Although these values were originally randomly assigned they were modified during the process of generating the model's memory, consequently at this point provide a glimpse of the model's behavior. Parameter 16, which is the subject's group compatability factor, reflects the subject's acceptance of a group composed of the first 24 models.

Table 5 contains the three models' reactions to a teacher whose personality, academic record, and attitude are average. In this case, ten classes were simulated with the models' reactions to the first and last being shown. Since the initial reactions to a particular stimulus are dependent upon preceding events, they typically oscillate about a set of values which are asymptotically approached by subsequent reactions. This accounts for the differences between the first and tenth values.

Since the equations for computing these reactions were previously presented, there appears to be no point in discussing them in great detail. However, two points merit emphasis.

Table 5. Reaction to stimulus type 222

Model no.	First stimulus LR	AC	AG	Tenth stimulus LR	AC	AG
S1	45.3036	46.6747	46.1598	45.1328	46.4079	44.6275
S2	44.8082	49.6403	52.7597	45.2479	51.0795	52.4793
S3	49.0672	54.4637	65.2618	50.0826	56.6982	65.6454

First, the subject's previous mood, which is obtained by averaging parameters 12 and 13 which are the peer and course attitudes from the previous reaction, and the compatibility factor heavily influence the subject's attitude toward his fellow participants. Because of this fact, alternating stimuli or shuffling subjects from group to group can be expected to produce different values for this variable.

The other point involves the learning rate. From this table subjects with extreme IQ's can be compared, revealing a very small difference in learning rate. This does not imply that the subject whose IQ is over 100 learned no more than the individual with an IQ of less than 62, but that they each realized approximately the same proportion of their potential.

Table 6 shows the effect of the validity jeopardizing factors acting on a group of 24 subjects through an experiment consisting of a pretest, ten stimuli, and a posttest. The experiment was repeated ten times in order to demonstrate the

Table 6. Group effects of the validity jeopardizing factors (percent of influence)

VJF	Learning rate	Course attitude	Peer attitude
1	0.28	-5.80	-1.14
2	-0.22	5.31	0.54
3	5.09	-1.69	-0.03
4	-0.26	-15.94	-1.81
5	-117.14	-7.73	-0.08
6	0.00	0.00	0.00
7	-3.79	100.24	9.37
8	-0.92	1.21	-0.52
ALL	-116.52	66.67	7.30

effect of each factor operating independently, a combination of all factors, and a true unbiased experiment. The entries in the table are the percent of deviation, caused by the validity jeopardizing factors, from the true experimental effect for the group.

From the first row of the table it can be seen that under the influence of validity jeopardizing factor one, which is maturation, the group experienced a small decrease in their feelings toward each other, a decrease of almost six percent in their view of the course and a very small increase in their rate of learning. These changes are the results of comparing the biased reaction with the unbiased reaction to the same stimulus. While the resulting value has a somewhat predictable magnitude, its sign is not so easily appreciated.

The maturation factor increases parameters five, six, and nine. From the equations presented in the first section of this chapter, it can be seen that increasing parameter five gives more significance to the subject's previous mood in determining its peer attitude. Since the value of previous mood is less in this example than the teacher personality factor and the subject's group compatibility factor, a heavier emphasis on mood decreases the peer attitude. Likewise, parameters six and nine specify the importance of peer and teacher attitude in computing the subject's course attitude. In this example, these quantities are smaller on the average than the values attributed to the subject's mood and its second memory element; hence increasing these parameters decreases the average calculated course attitude.

Learning rate is not affected directly by maturation. Parameters five, six, and nine are not included in its formulas; however, the course attitude component of the reaction is involved. In this example, maturation decreased the course attitude which in turn decreased the computed learning rate. Since the effect of the stimulus was to decrease the learning rate, and the validity jeopardizing factor magnifies this effect, it carries an implied positive sign. Conversely, the negative sign of some of the entries in Table 6 reflect that the unbiased experimental effects diminished in magnitude under the influence of the validity jeopardizing factors, irrespective of whether the unbiased effects have a negative influence on the group.

Two other observations should be made concerning this table. First, one should not assume that these influences are typical. They depend heavily upon the experimental design, the models involved, and the stimulus. They are presented here, in order to show the relative effect of the factors in a particular situation, thus generalizations should be made cautiously. The other point which merits consideration is the null effect of factor six. This factor represents statistical regression and operates only on models whose learning rate is highly abnormal. Since the memories of the models in this example were generated to have a low group variance, none of them are far enough above or below the norm to receive this modification.

In general, most of the models react to a stimulus in the same manner. Some exaggerate the effect, others are conservative, while a few can be considered rebellious. The same is true for the validity jeopardizing factors. For this reason, comparing randomly selected groups of sufficient size under identical conditions should produce equivalent results. However, if the groups are biased or if the experimental conditions are dissimilar, a statistically significant difference can be expected. One way in which conditions can be made dissimilar is by activating the validity jeopardizing factors for selected groups only.

VI. EXAMPLE, OBSERVATIONS, RECOMMENDATIONS, AND SUMMARY

A. Example

A discussion of this project could not be considered complete without the inclusion of an illustration of its use. Since this is a computer dependent project, it seems appropriate to consider, as an example, an educational problem which has arisen as a by-product of computer usage. One such family of problems involves the implementation of computerized scheduling. As a representative of this family, the following research problem has been synthesized.

1. Research problem

a. Introduction The faculty of the Riverside Junior High School is considering implementing a complex modular scheduling system for the 1970-71 school year. Under this system students would be scheduled for classes daily with the time of class meetings dependent upon a student's needs and the availability of resources required to meet these needs. For example, the computer to be used in the mathematics program will be provided by a local industry and, consequently, will be available only during the fourth period of the day. A mathematics student requiring the services of the computer must be scheduled for fourth period mathematics class. Priorities for assigning members to these classes are to be established by the instructors. One constraint has been imposed.

Each student must retain the same teacher, but the time of meeting and class membership would be subject to daily changes.

Acceptance of the system is contingent upon the approval of Mr. Irving M. Dubious, the school principal. Mr. Dubious expressed concern that the continual transition of class participants would have an adverse effect upon student behavior. As a result, he has requested that a study be conducted during the present school year to resolve this concern.

During the current year, 128 eighth grade students are scheduled into four equal groups. These groups cycle through English, social studies, mathematics, and science classes during the last four periods of the school day. Of these classes, only the four social studies sections are taught by the same instructor, thus meeting the constraint of the proposed system. However, all teachers have agreed to standardize the material and permit their classes to be arbitrarily scheduled for a two week period in order that the social studies sections can be used for experimentation.

b. Statement of problem   As research director for the school, you are to design an experiment to reveal the effect of changing class membership. Assume reliable, valid, multiform tests are available to measure a student's achievement,[1] attitude toward the class, and attitude toward his peers.

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[1]For this example the subject's learning rate is interpreted to be achievement.

Prior to manipulating the actual school environment you are to carry out the experiment on a simulation of the Riverside student body, and interpret the results. A description of the simulation, the language used in transmitting a research design to the simulation, a coded example, and some standard coding forms are included in the remainder of this paper.[1]

2. Description of simulation

The simulation includes 128 models of students which have the following characteristics:

a. Each model perceives only three dimensions of the stimulus, which in this case, is the teacher. These dimensions of the teacher are:

   (1) his personality which may have a value of 1, 2, or 3 signifying levels from unpleasant to pleasant,

   (2) his college academic record which, from low to high, assumes the values of 1, 2, 3, or 4,

   (3) his attitude toward the course he is teaching which may be 1, 2, or 3 ranging from unfavorable to favorable.

For this experiment you may assume the social studies teacher to be of any type you desire.

---

[1]Only the description of the simulation is included here. The language, coded example, and a standard coding form appear in Appendix A.

b. The only measurable qualities of the models are achievement, attitude toward the course, and attitude toward the other models. All measurements will fall within the range from 0 to 100 with 0 being very poor and 100 being most favorable.

The simulation provides facilities for separating the models into groups. These groups may be tested, administered a stimulus, and compared for equality. These functions are initiated through an ordered set of user constructed statements which are described in a separate section. The activities performed must conform to the following general restrictions:

(1) groups must be defined prior to testing or treatment,

(2) a model must be affiliated with no more than one group at a given time,

(3) all groups must contain the same number of members,

(4) groups must be tested before they can be compared.

3. Sample solution

Frequently, an invalid attempt to solve a problem is more assistance in defining and bounding the problem than a smooth straight forward solution. In light of this observation, an experiment has been devised which violates the problem

Group number	
1	R O X R X R X R X R X R X R X R X R X R X O
2	R O X R X R X R X R X R X R X R X R X R X O
3	R O X X X X X X X X X X O
4	R O Y Y Y Y Y Y Y Y Y Y O

Figure 5. An experimental design for investigating scheduling

The symbols used in this figure have the following interpretations:

R denotes random assignment which in this case consists of a shuffling of group membership.

O signifies testing.

X symbolizes an encounter with a teacher having a pleasant personality, high academic record, and favorable attitude toward the course taught. (Stimulus 3, 4, 3)

Y symbolizes an encounter with a teacher having a pleasant personality, low academic record, and favorable attitude toward the course taught. (Stimulus 3, 1, 3)

constraints on the social studies teacher but reveals some interesting properties of the simulation. The design for this experiment is shown symbolically in Figure 5.

The experiment consists of four randomly selected groups containing 32 students each. All four groups are given a pretest prior to treatment and a posttest at the conclusion of the experiment. The first three groups are taught by an instructor having a pleasant personality, a high academic record, and a favorable attitude toward the course, while the fourth group has a teacher with comparable qualities except for his academic record which is very low. The membership of the first two groups is randomly shuffled at the beginning of each day.

A comparison of group 3 with either 1 or 2 is intended to reveal the effect of shuffling classes while comparing groups 3 and 4 may reflect the simulated importance that an individual's academic success in college has upon his effectiveness as a teacher. The experimental results as they are influenced by the validity jeopardizing factors are shown in Table 7. The "unbiased" results for this experiment are shown in Table 8.

4. Discussion

Table 7. Summary of t-values obtained from conducting the experiment whose design is shown in Figure 5 with maturation and selection-maturation interaction factors active

	(62 df) Groups		
	2	3	4
Group 1	1.3580 -0.3929 0.5668	1.6321 -0.8547 -1.4906	9.6072 -0.4312 -0.8517
Group 2		0.3528 -0.5644 -2.1999	8.9743 -0.0642 -1.6525
Group 3			8.0152 0.4851 0.8208

For the experiment which produced the data shown in Table 7, maturation and selection-maturation interaction were the active validity jeopardizing factors. The entries in each cell, from top to bottom, are the statistics for achievement, course attitude, and peer attitude. The achievement of group 4 is significantly better than that of the other groups. The peer attitude of group 1 is significantly better at the .05 level than that of group 3.

Table 8. Summary of t-values obtained from conducting the experiment whose design is shown in Figure 5 with validity jeopardizing factors inactive

	(62 df) Groups		
	2	3	4
Group 1	1.3356 -0.4779 0.4718	2.0173 -0.0201 -0.6620	10.4699 0.5205 0.1268
Group 2		0.7973 0.4170 -1.1694	9.7379 1.0497 -0.3787
Group 3			8.0645 0.5011 0.8285

The data shown in Table 8 was generated while all validity jeopardizing factors were inactive. The entries in each cell, from top to bottom, are the statistics for achievement, course attitude, and peer attitude. The achievement of group 4 is superior to that of the other groups and the achievement of group 3 is significantly better than that of group 1 at the .05 level.

Inspection of the equations which determine a model's reaction to stimuli leads one to suspect that the shuffling of classes would produce little change. In order to support this point of view, the computation of peer attitude which was introduced in Chapter Five is reviewed. This computation occurs in two steps according to the following equations.

$$IR = \frac{PC\times 100 + TTP\times PTPA + PM\times PMPA}{1 + PTPA + PMPA}$$

$$C3 = IR\times(1 - PGEN) + XMPA\times PGEN$$

In these equations, PTPA, PMPA, and PGEN are parameters of the model. TTP is the teacher's personality, PM is the model's previous mood, and XMPA is a summary of previous experiences. The only factor which should be directly affected by the shuffling of classes is PC which is a measure of the model's compatibility with its group. As the groups change membership, this factor changes in value. However, it could be a random change which balances out over the 10 regroupings of the experiment. In addition to this the magnitude of the influence of PC is severely dampened by the other factors. It should be noted on the other hand, that the peer attitude component, C3, for one reaction contributes 50 percent to the PM factor for the following reaction, thus giving compatibility a residual effect.

For this experiment, maturation and selection-maturation interaction were activated. The rationale for doing this lies in the fact that these factors modify PTPA and PMPA. By decreasing PTPA and PMPA the contribution of PC is increased. Since selection-maturation interaction is invoked after each grouping occurs, it was hoped that the influence would be great enough to produce positive results for the experiment. In this example the validity jeopardizing factors are not used to obscure the true experimental results, as is normally the case, but to produce a borderline statistical significance. Thus, this problem is not one of design construction, although this could be incorporated by activating the testing factor, but one of interpretation of results.

From Tables 7 and 8 it can be quickly seen that a teacher's academic record influences the model's achievement; however, it does not appear to have any measurable influence on either the course attitude or peer attitude. These observations are independent of the validity jeopardizing factors and class scheduling.

Since groups 1 and 2 are randomly intermixed throughout the experiment, they have no identity except for administrative purposes. For this reason, conclusions drawn from comparing groups 1 and 3 should be the same as those formed from a comparison of groups 2 and 3. This, however, is not the case for either the "biased" or "unbiased" experiment. These differences can be attributed to sampling errors but this does not resolve the basic question: Are the observed differences statistically significant?

As an example of an approach which a researcher might pursue, an analysis of covariance was performed on the data obtained from the experiment in which the validity jeopardizing factors were active (Table 7). The individual differences in IQ were controlled in an effort to determine if the continual rescheduling of classes produced a significantly inferior peer attitude. The results shown in Table 9 reveal that this was, in fact, the case.

Table 9. Test of significance of flexible modular scheduling on the students peer attitude

Source of variation	Residuals Degrees of freedom	Residuals Sums of squares	Residuals Mean square	F
Total	95	4.410152		
Within groups	93	4.114783	.044245	
Difference	2	.295369	.147685	3.34[a]

[a]This value is significant at the .05 level.

B. Observations

The research problem contained in the preceding section was presented to five first year graduate students in an educational research training program. This presentation was made during a fifty minute period slightly more than a week prior to the end of a quarter. The students were invited, not required, to submit solutions to the problem. In spite of end-of-the-quarter pressures, four of the five students returned coded designs, the results of which were discussed the following week. This experience along with the processing of examples such as the preceding one serve as a basis for the ensuing observations concerning the simulation, student's reaction, and instructional strategy.

The example demonstrates the need for harmony between the simulated environment and the problem being assigned. In this case, the problem concerning the daily restructuring of class membership would appear to be in tune with the environment. Since the experimental results approach significance at the .05 level, the student is presented an interesting and pertinent problem. As a solution, he might lower the criteria for significance, seek more sensitive statistical measures, redesign the experiment, or report no significant differences. The alternative selected should prove enlightening to the student and might prove enlightening to his evaluator.

It can also be seen from the example that this environment is not ideal for comparing teacher types. The significance is so great that it can be identified using almost any type of two group design which logically conforms to the problem. The models involved in this experiment were preconditioned by exposing them to 10 stimuli of each possible type and then to 20 additional stimuli of an arbitrarily chosen type. By increasing the preconditioning stimuli to 20 and 150 respectively, all significant t-values can be decreased. For example, by using this environment with all validity jeopardizing factors inactive the t-value for comparing the achievement of groups 3 and 4 can be decreased from 8.0645 shown in Table 8 to 2.1792. The latter environment is more appealing for this type of experiment.

Currently the environment is tuned by trial and error. For experimental purposes this is probably an economical approach to the problem since the experimenter learns about the simulation through this process and rarely are more than two trials needed to produce an acceptable model. If the simulation were to be widely used for instructional purposes an automated solution would be in order.

Another consideration is the time required to process an experiment. Under the current implementation it requires approximately ten seconds of processing time to execute the experiment which is symbolically outlined in Figure 5. The locally assigned cost is approximately $1.50. Although this is not considered to be exorbitant, minimization is desirable. Additional experience may provide justification for removing some of the simulation's flexibility permitting a more efficient system.

Any generalizations based on the behavior of the research students which were presented this problem would be precariously founded. The students were not typical, the setting was a seminar rather than a structured class, and the presentation was not integrated into the curriculum. In view of this, the following facts are noted without elaboration.

1. Four out of the five students returned coded designs, two of which were error free.
2. Both the successes and failures were stimulants for fruitful discussion.
3. The students appeared to bypass the simulation and communicate in terms of the hypothetical school.
4. Although validity jeopardizing factors, per se, had not been previously studied, several were introduced by the students as an explanation for observed phenomena.
5. The program output proved somewhat difficult to decipher.

As a result of this experience, the following suggestions are presented for consideration in making future assignments.

1. Only the research problem and the descriptions of the

simulation should be given to the student on the initial encounter.

2. The student should write the hypothesis and diagram the experimental design with which he proposes to test it.
3. Once the design is completed a description of the simulation language and a coded example can be presented.
4. The student should code his design which can then be submitted to the computer.
5. The computer output must be briefly explained to the student.
6. A written summary of the experimental results and conclusions should be requested. (This could be a memo to Mr. Dubious.)
7. The hypothesis, design, results, and conclusions should be exposed to peer scrutiny and discussion.
8. The process should be repeated using a sequence of carefully graded problems.

C. Recommendations for Further Research

Since the purposes of this project relate primarily to its design, the next logical step is its internal as well as external evaluation. An internal evaluation would consist of establishing the simulation as an aid to the learning process. It would involve isolating and modifying the objectionable features and emphasizing the favorable ones, proving that the simulation does promote learning, if in fact this is the case, and identifying the educational objectives which it supports.

If the internal evaluation is successful, an external evaluation is in order. This should be accomplished by comparing the simulation with other instructional methods which support the same educational objectives. This step is necessary in order to establish the conditions under which this simulation should be used and to identify its optimal role in an instructional strategy.

Hopefully, from this type of research, generalizations could be formed which would pertain to a variety of instructional simulations. For example, identification of the supported objectives should indicate areas for further development and, isolation of this design's strengths and weaknesses should serve as guidelines for developing simulations in these areas. Research in this area may be very difficult with the strong influences being couched in the student's individual differences. By the same token, successful research would propel CAI toward its goal of truly individualized instruction.

D. Summary

The objectives for this project fall into two categories. One set supports the construction of a learning aid, the other a research vehicle. The simulation which was developed meets both criteria. It enables students of behavioral research to group, test, and prescribe a treatment for a collection of computer models in a manner which parallels behavioral experiments in the real world. Like real world subjects, the models respond to stimuli other than the experimental variable, thus casting a shadow over the true effect. Unlike their real world patterns, however, the models may be restored to their pre-experimental condition. The results of an experiment are summarized if it is successfully completed, otherwise error messages are printed. Evidence was obtained to prove that students could analyze a research problem, formulate a solution, and successfully communicate it to the simulation with less than an hour of instruction. No attempt was made to determine whether this activity was beneficial to the student.

Likewise the value which the simulation will have as a research vehicle has not been established. Since it is functional, however, it will support research related to its use. It will enable investigations involving student reactions to simulation as well as those involving instructional techniques.

The evaluation of a developmental project rests with the acceptance of its product in light of its design objectives. In this case, the judgment must be made on the basis of whether it creates a path to new knowledge. If it serves the student as a useful learning aid in the field of experimental research, it can be considered successful. If it serves the educator as a useful learning aid in the area of instructional simulation, it must be considered a success.

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IX. APPENDIX A: DESCRIPTION OF PROGRAM INPUT

A. Description of Generator Statements

Statement name	Columns	Description
GPAR		This must be the first statement entered since it contains the generation parameters for the environment
	1-4	"GPAR"
	6-10	The number of models to be produced
	11-15	The number of stimuli of each type to be used to precondition the models
	16-20	The number of stimuli of a random type to be used to precondition the models
	21-25[1]	A unit for measuring a model's deviation from the group's average IQ - This partially determines the model's group acceptance factor
	26-30[1]	A unit for measuring a model's deviation from the group's average learning rate
	31-35[1]	A unit for measuring a model's deviation from the group's average course attitude
	36-42	The maximum levels of the characteristics of the stimulus
	46-55	The validity jeopardizing factor switch settings

[1]These values are real numbers. If a decimal point is not included it is assumed to be at the end of the field.

Statement name	Columns	Description
COST		The elements of the hypothetical experimental cost are established by this statement
	1-4	"COST"
	6-10[1]	The cost for forming an experimental group - This is assessed each time a group is formed or reformed
	11-15[1]	The cost of procuring each subject used in the experiment
	16-20[1]	The cost associated with testing a subject of the experiment
	21-25[1]	The cost of administering a stimulus to a subject of the experiment
LEAG		With this statement the instructor can specify the groups to be affected by reaction to experimental arrangement
	1-4	"LEAG"
	6-10 11-15 ⋮ 61-65	The identification numbers of the groups which are to be affected by the validity jeopardizing factor
LSMG		This statement can be used to specify the groups which are to be affected by selection-maturation interaction
	1-4	"LSMG"
	6-10 11-15 ⋮ 61-65	The identification numbers of the groups which are to be affected by this validity jeopardizing factor

[1]These values are real numbers. If a decimal point is not included it is assumed to be at the end of the field.

B. Description of Interpreter Statements

Statement name	Columns	Description
NAME		This must be the first statement of any experiment. It identifies the experimenter and initializes the experimental environment.
	1-4	"NAME"
	5-35	The experimenter's name
	*	(See Note 1)
DSGN		This statement conveys to the simulation the over-all design of the experiment. It must be the second statement of the experiment.
	1-4	"DSGN"
	5-7	The number of experimental groups
	8-10	The number of subjects per group (This is constant for all groups.)
	11-13	Request for individual test scores (If this field contains a one, individual test scores will be printed; otherwise only the summary scores will be shown.)
	*	(See Note 1)
GRUP		GRUP is used to assign group membership. If random assignment is desired, this statement can be omitted. Under random assignment the first group consists of subjects 1 through n, the second group consists of subjects n + 1 through 2n, etc. (See Note 2)
	1-4	"GRUP"

Statement name	Columns	Description
	5-7	The identification number of the group being defined
	8-10 11-13 ⋮ 74-76	The identification numbers of the subjects (1-128) belonging to this group (If the group consists of more than 23 members, additional cards must be used.)
	*	(See Note 1)
RGRP		This statement provides the experimenter the facility to randomly reassign group membership during the course of the experiment.
	1-4	"RGRP"
	5-7	The type of redistribution of subjects desired (A value of 1 denotes that the new memberships of the groups, which are arguments of this function, are to be selected by shuffling and reassigning the original members. A value of 2 denotes that unassigned subjects as well as original members may be used in determining the new memberships.)
	8-10 11-13 ⋮ 74-76	The identification numbers of the groups being redefined
	*	(See Note 1)
STIM		STIM contains the treatment and the identification numbers of the groups receiving it.
	1-4	"STIM"

Statement name	Columns	Description
	5-7	The teacher characteristics Col. 5 personality values - 1, 2, or 3 Col. 6 academic record values - 1, 2, 3, or 4 Col. 7 attitude toward the course values - 1, 2, or 3
	8-10	Blank
	11-13	The number of repetitions of this stimulus (example - This field would contain a 5 if the group were to have the same type of teacher for 5 consecutive days.)
	14-16 17-19 ⋮ 74-76	The identification numbers of the groups to be treated (See Notes 2 and 3)
	*	(See Note 1)
TEST		This statement initiates a test and defines the groups to be tested
	1-4	"TEST"
	5-7	The type of test (A value of 1 denotes a pretest where only the scores of this test are of interest. A value of 2 denotes a posttest which implies that test scores and average changes from the previous test are to be recorded.)
	8-10 11-13 ⋮ 74-76	The groups to be tested (See Notes 2 and 3)
	*	(See Note 1)

Statement name	Columns	Description
COMP		The COMP statement may be used to compute a t-test statistic for any two groups which have been defined and tested. If the groups have been tested two or more times, a statistic for pretest-posttest differences will also be computed.
	1-4	"COMP"
	5-7 8-10 . . . 74-76	These fields are to contain the identification numbers for the groups being compared. (Entries are processed in pairs from left to right as they appear in the fields.)
	*	(See Note 1)
TERM		This statement terminates the experiment, causing all test scores to be printed out. It must be the last statement for an experiment.
	1-4	"TERM"
	*	(See Note 1)

Note 1. On all statements the columns 77-80 are unassigned and may be used by the experimenter for identification. As an example, columns 77-78 might contain the experiment number and 79-80 the input statement number.

Note 2. If random group assignment is used the group will be assigned the identification numbers 1, 2, 3 . . . . If the GRUP function is used the experimenter may identify the group by any 2 digit (or less) numbers he desires.

Note 3. If group numbers are not included it will be assumed that all defined groups are to be affected.

C. Example of a Coded Design

The experimental design shown in Figure 6 is an arbitrary design whose sole purpose is to illustrate the use of the above statements for transmitting a design to the simulation. This design was not formed to test a particular hypothesis, and any attempt on the part of the reader to determine such a purpose would be misdirected.

R	O	X_1	O	R	X_1	O
R		X_2	O	R	X_2	O

Figure 6. Experimental design (R signifies randomized grouping, O observation, and X treatment)

Assume for this example that two randomly selected groups of 25 members each are to be involved. The first group is to receive a pretest, five replications of a treatment, and a posttest. The second group is to receive five replications of a different treatment followed by a test. The groups are then to be compared on the basis of their final test scores. Following this comparison the membership of the two groups is to be shuffled, with the treatment, testing, and comparison to be repeated. The coding of the design is shown on the following page.

80 COLUMN DATA SHEET

PROGRAM	JOB NO.	BY	DATE
Experimental Design	ONE	M. T. SELL	3-25-70

NAME		M.T.SELL		
DSGN	2	25		
TEST	1	1		
STIM	1.1.1		5	1
STIM	3.4.3		5	2
TEST	2			
COMP	1	2		
RGRP	1	1	2	
STIM	1.1.1		5	1
STIM	3.4.3		5	2
TEST	2			
COMP	1	2		
TERM				

D. Standard Coding Form

80 COLUMN DATA SHEET

PROGRAM	JOB NO.	BY	DATE

1 10 20 30 40 50 60 70 80

X. APPENDIX B: EXAMPLES OF PROGRAM INPUT AND OUTPUT

A. Input to Environment Generation Program

8 0 COLUMN DATA SHEET

PROGRAM	JOB NO.	BY	DATE
Environment Generation – Gen (130, 10, 20)		R. Thomas	3-20-79

```
GPAR   130   10   20   10   2.5   2.5393      1000000100
```

B. Output of Environment Generation Program

THE FOLLOWING ENVIRONMENT WAS GENERATED

130 SUBJECTS WERE GENERATED.

10 STIMULI OF EACH POSSIBLE TYPE WERE ADMINISTERED TO EACH SUBJECT TO FORM HIS MEMORY.

20 REPLICATIONS OF A RANDOMLY CHOSEN TYPE WERE USED TO MODIFY EACH SUBJECT'S MEMORY.

THE MAXIMUM LEVELS OF THE DIMENSIONS OF A STIMULUS ARE 3, 4,
AND 3 PRODUCING 36 DISTINCT TYPES OF STIMULI.

THE ACTIVE VALIDITY JEOPARDIZING FACTORS ARE 1, 8

THE FOLLOWING COSTS WERE ESTABLISHED FOR THIS EXPERIMENT:
THE FORMATION OF A GROUP $ 0.00
FOR EACH SUBJECT USED $ 0.00
TESTING COST PER SUBJECT PER TEST $ 0.00
TREATMENT COST PER SUBJECT PER STIMULUS $ 0.00

C. Input to the Experiment Interpreter

80 COLUMN DATA SHEET

Page 1/2

PROGRAM	JOB NO.	BY	DATE
Experiment Interpreter - Scheduling		R. Thomas	3-20-70

NAME		REX	THOMAS		
DSGM	4	32			
TEST					
STIM343			1	1	2
STIM343			10	3	
STIM313			10	4	
RGRP	1	1	2		
STIM343			1	1	2
RGRP	1	1	2		
STIM343			1	1	2
RGRP	1	1	2		
STIM343			1	1	2
RGRP	1	1	2		
STIM343			1	1	2
RGRP	1	1	2		
STIM343			1	1	2
RGRP	1	1	2		
STIM343			1	1	2
RGRP	1	1	2		
STIM343			1	1	2
RGRP	1	1	2		
STIM343			1	1	2
RGRP	1	1	2		
STIM343			1	1	2

80 COLUMN DATA SHEET

Page 2/2

PROGRAM	JOB NO.	BY	DATE
Experiment Interpreter – Scheduling		R. Thomas	9-20-70

```
TEST  2
COMP  1  2  1  3  1  4  2  3  2  4  3  4
TERM
```

D. Output of Interpreter - Experimental Results

EXPERIMENTER - REX THOMAS

THE FOLLOWING GROUPS WERE IMPLICITLY DEFINED : 1, 2, 3, 4

THE FOLLOWING GROUPS WERE TESTED : 1, 2, 3, 4

THE FOLLOWING GROUPS RECEIVED 10 REPLICATIONS OF TREATMENT 313000 : 4

THE FOLLOWING GROUPS RECEIVED 10 REPLICATIONS OF TREATMENT 343000 : 3

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

TEST SCORES FOR GROUP 1

TEST 1

SUBJ NO. 1LEARN RATE COURSE ATT. GROUP ATT.

AVERAGE SCORES

(32 SUBJECTS)

47.997030 48.849420 49.424860

SUMS OF SQUARES OF (SCORES/50)

29.4940 30.5482 31.2693

AVE CHANGE FROM PREVIOUS TEST SCORE

-1.000000 -1.000000 -1.000000

SUMS OF SQUARES OF DEVIATIONS

-1.0000 -1.0000 -1.0000

TEST SCORES FOR GROUP 2

TEST 1
SUBJ NO. ILEARN RATE COURSE ATT. GROUP ATT.

AVERAGE SCORES

(32 SUBJECTS)

47.751640 49.075570 49.454170

SUMS OF SQUARES OF (SCORES/50)

29.1984 30.8333 31.3067

AVE CHANGE FROM PREVIOUS TEST SCORE

-1.000000 -1.000000 -1.000000

SUMS OF SQUARES OF DEVIATIONS

-1.0000 -1.0000 -1.0000

THE FOLLOWING GROUPS WERE REDEFINED : 1, 2

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

THE FOLLOWING GROUPS WERE REDEFINED : 1, 2

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

THE FOLLOWING GROUPS WERE REDEFINED : 1, 2

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

THE FOLLOWING GROUPS WERE REDEFINED : 1, 2

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

THE FOLLOWING GROUPS WERE REDEFINED : 1, 2

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

THE FOLLOWING GROUPS WERE REDEFINED : 1, 2

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

THE FOLLOWING GROUPS WERE REDEFINED : 1, 2

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

THE FOLLOWING GROUPS WERE REDEFINED : 1, 2

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

THE FOLLOWING GROUPS WERE REDEFINED : 1, 2

THE FOLLOWING GROUPS RECEIVED 1 REPLICATIONS OF TREATMENT 343000 : 1, 2

THE FOLLOWING GROUPS WERE TESTED : 1, 2, 3, 4

T-TEST STATISTICS FOR GROUPS 1 AND 2 -LAST TEST - L RATE =	-1.8990	COURSE A =	0.0567	PEER A =	-0.1999	DF =	62
-CHANGE FROM PREVIOUS TEST - L RATE =	1.3580	COURSE A =	-0.3929	PEER A =	0.5668		
T-TEST STATISTICS FOR GROUPS 1 AND 3 -LAST TEST - L RATE =	-2.0560	COURSE A =	-0.7419	PEER A =	-0.8376	DF =	62
-CHANGE FROM PREVIOUS TEST - L RATE =	1.6321	COURSE A =	-0.8547	PEER A =	-1.4906		
T-TEST STATISTICS FOR GROUPS 1 AND 4 -LAST TEST - L RATE =	1.3386	COURSE A =	-0.3387	PEER A =	-0.8172	DF =	62
-CHANGE FROM PREVIOUS TEST - L RATE =	9.6072	COURSE A =	-0.4312	PEER A =	-0.8517		
T-TEST STATISTICS FOR GROUPS 2 AND 3 -LAST TEST - L RATE =	-0.6064	COURSE A =	-0.7835	PEER A =	-0.6194	DF =	62
-CHANGE FROM PREVIOUS TEST - L RATE =	0.3528	COURSE A =	-0.5644	PEER A =	-2.1999		
T-TEST STATISTICS FOR GROUPS 2 AND 4 -LAST TEST - L RATE =	3.7064	COURSE A =	-0.3875	PEER A =	-0.5972	DF =	62
-CHANGE FROM PREVIOUS TEST - L RATE =	8.9743	COURSE A =	-0.0642	PEER A =	-1.6525		
T-TEST STATISTICS FOR GROUPS 3 AND 4 -LAST TEST - L RATE =	3.4762	COURSE A =	0.3903	PEER A =	0.0270	DF =	62
-CHANGE FROM PREVIOUS TEST - L RATE =	8.0152	COURSE A =	0.4851	PEER A =	0.8209		

TEST SCORES FOR GROUP 1

TEST 1

SUBJ NO. ILEARN RATE COURSE ATT. GROUP ATT.

AVERAGE SCORES

(32 SUBJECTS)

48.483840 49.365640 49.639930

SUMS OF SQUARES OF (SCORES/50)

30.0950 31.1969 31.5418

AVE CHANGE FROM PREVIOUS TEST SCORE

0.797471 0.392153 0.221532

SUMS OF SQUARES OF DEVIATIONS

23.1555 5.6984 3.0590

TEST SCORES FCR GROUP 2

TEST 1

SUBJ NO. 1LEARN RATE CCURSE ATT. GROUP ATT.

AVERAGE SCORES

(32 SUBJECTS)

48.764490 49.357720 49.655270

SUMS OF SQUARES OF (SCORES/50)

30.4404 31.1872 31.5616

AVE CHANGE FROM PREVIOUS TEST SCORE

0.702198 0.406219 0.194621

SUMS OF SQUARES OF DEVIATIONS

17.8564 5.7744 1.9597

TEST SCORES FOR GROUP 3

SUBJ NO.	TEST 1 1LEARN RATE	COURSE ATT.	GROUP ATT.	TEST 2 2LEARN RATE	COURSE ATT.	GROUP ATT.
65	48.752790	48.668740	49.122780	49.082180	49.054000	49.531530
66	47.287530	49.612800	49.932030	48.242840	49.824610	49.950460
67	48.531640	48.397000	48.780090	48.957030	48.913080	49.082440
68	49.378690	49.965560	49.384820	49.733480	50.253570	49.763680
69	47.316420	49.179870	49.088070	48.255640	49.537090	49.201490
70	47.262690	49.199060	49.139290	48.291730	49.489010	49.372320
71	46.882400	49.141120	49.625800	48.009790	49.336740	49.605280
72	45.512550	49.773980	49.363570	46.731410	49.968910	49.460410
73	47.431380	47.583510	49.830880	48.187020	48.144220	49.522440
74	48.009940	49.141580	48.909600	48.944000	49.805630	49.543650
75	50.304150	50.459960	49.586650	50.752010	50.985240	50.303370
76	47.837750	48.165720	49.010130	48.490610	48.695320	49.334480
77	47.259490	47.897520	49.314810	48.203780	48.446600	49.487420
78	48.907440	48.892190	49.087400	49.339780	49.357260	49.587570
79	47.572790	49.132670	49.139140	48.475030	49.586510	49.539290
80	48.419540	48.887100	49.682030	48.864530	49.127250	49.747370
81	48.386550	48.449400	49.535400	48.904320	48.975080	49.844920
82	48.432290	48.991620	49.922240	49.295340	49.743390	50.642210
83	48.626720	49.492270	49.469580	49.167600	49.772810	49.722150
84	47.499290	49.238400	49.518120	48.505950	49.710290	49.906350
85	48.206510	49.189680	49.395330	48.990140	49.707990	50.029110
86	49.146130	48.939910	49.322030	49.401480	49.341590	49.506540
87	49.090200	49.233520	49.583460	49.440960	49.650780	49.814740
88	49.339490	50.316310	50.564490	49.812560	50.549920	50.688060
89	48.399420	48.266440	49.318830	48.901770	48.890210	49.928400
90	48.461310	49.160150	49.180640	49.061820	49.639640	49.680310
91	49.747130	49.835140	49.444290	49.870390	49.977720	49.655160

NOTE: EXAMPLE OF INDIVIDUAL TEST SCORES

92	46.633750	49.098220	49.461880	47.680810	49.397030	49.513640
93	48.347160	48.180630	49.946510	48.818320	48.749720	50.113380
94	47.941370	49.519360	49.569730	48.713720	49.669310	49.691650
95	48.533700	49.110000	48.952780	49.335870	49.792310	49.663200
96	48.237670	48.255470	48.615760	48.940320	48.984320	49.260070

AVERAGE SCORES

(32 SUBJECTS)			(32 SUBJECTS)		
48.177960	49.043480	49.359840	48.856210	49.471050	49.709040

SUMS OF SQUARES OF (SCORES/50)

29.7219	30.7929	31.2383	30.5594	31.3308	31.6303

AVE CHANGE FROM PREVIOUS TEST SCORE

-1.000000	-1.000000	-1.000000	0.678261	0.427571	0.309216

SUMS OF SQUARES OF DEVIATIONS

-1.0000	-1.0000	-1.0000	17.2086	6.7762	5.0038

TEST SCORES FOR GROUP 4

	TEST 1			TEST 2		
SUBJ NO.	1LEARN RATE	COURSE ATT.	GROUP ATT.	2LEARN RATE	COURSE ATT.	GROUP ATT.

AVERAGE SCORES

(32 SUBJECTS)			(32 SUBJECTS)		
48.050610	49.005320	49.442240	48.257270	49.413720	49.706580

SUMS OF SQUARES OF (SCORES/50)

29.5590	30.7448	31.2922	29.8132	31.2582	31.6271

AVE CHANGE FROM PREVIOUS TEST SCORE

-1.000000	-1.000000	-1.000000	0.206714	0.408377	0.264351

SUMS OF SQUARES OF DEVIATIONS

-1.0000	-1.0000	-1.0000	2.3135	5.9637	3.2548

XI. APPENDIX C: VALIDITY JEOPARDIZING FACTOR DECISION TABLES

The validity jeopardizing factors are intended to foster realism as well as to enable the instructor to stage experimental situations which emphasize a particular point. In order to provide this flexibility, most of the decisions have been incorporated into easily modifiable tables. The present contents as well as a brief explanation of the tables are contained in this section. In order to facilitate references Table 10 is included to provide a convenient listing of the validity jeopardizing factors and their associated numbers.

Table 10. Validity jeopardizing factors

Reference number	Validity jeopardizing factor
1	Maturation
2	Experimental Arrangement
3	Testing Sensitivity
4	Multiple Treatment Interaction
5	Testing
6	Statistical Regression
7	History
8	Selection-Maturation Interaction
9	Experimental Mortality
10	Instrumentation

Table 11. IVJFSW (Validity jeopardizing factor switches)

Validity jeopardizing factor 1	2	3	4	5	6	7	8	9	10
0	0	0	0	0	0	0	0	0	0

Table 11 contains the switches which activate or deactivate the validity jeopardizing factors. This array is initially filled with zeros designating the inactive state for all factors. It may be modified during the environment generation phase by instructor supplied data.

The rows of Table 12 correspond to the 12 experimental groups and the columns are associated with the experimental events. The entries of the table may consist of from zero to 9 validity jeopardizing factors, although a maximum of 4 is shown here. Entries of zero designate that there are no factors to be activated.

Examination of the table reveals an entry of 3456 for groups and specifies that it is to be administered after each test has been given. This means that the factors 3, 4, 5, and 6, as identified in Table 10, will be invoked following the testing of any group, provided that the factors are active for the experiment and that their maximum number of permissible envocations has not been exceeded. The activity of a

Table 12. IGS (Validity jeopardizing factors which may be activated for each group during each experimental stage)

	Phase of experiment					
Group no.	After grouping	Before testing	After testing	Before stimulus	After stimulus	(Unused)
1	28	0	3456	9	17	0
2	28	0	3456	9	17	0
3	28	0	3456	9	17	0
4	28	0	3456	9	17	0
5	28	0	3456	9	17	0
6	28	0	3456	9	17	0
7	28	0	3456	9	17	0
8	28	0	3456	9	17	0
9	28	0	3456	9	17	0
10	28	0	3456	9	17	0
11	28	0	3456	9	17	0
12	28	0	3456	9	17	0

factor is determined by Table 11 and the limits on invocations are contained in Table 13. The last column of the IGS table is retained for future program modifications.

Table 13 contains the maximum number of times a validity jeopardizing factor may be invoked for each group. For example, the entry corresponding to factor 1, which is maturation,

Table 13. IVJFG (Maximum number of invocations by factor by group)

Validity jeopardizing factors	Group number											
	1	2	3	4	5	6	7	8	9	10	11	12
1	50	50	50	50	50	50	50	50	50	50	50	50
2	9	9	9	9	9	9	9	9	9	9	9	9
3	50	50	50	50	50	50	50	50	50	50	50	50
4	50	50	50	50	50	50	50	50	50	50	50	50
5	50	50	50	50	50	50	50	50	50	50	50	50
6	9	9	9	9	9	9	9	9	9	9	9	9
7	50	50	50	50	50	50	50	50	50	50	50	50
8	50	50	50	50	50	50	50	50	50	50	50	50
9	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1

and group 2 is 50. This means that the members of group 2 cannot be subjected to the simulated influences of maturation more than 50 times during a single experiment. The factor would be activated after each of the first 50 stimuli that the group receives.

The parameters and elements of memory which are modified by an active validity jeopardizing factor are shown in Table 14. The entries in the table which are less than 100

Table 14. IVJFP (Model parameters which are affected by each factor)

Validity jeopardizing factors	Entries 1	2	3	4
1	5	6	9	0
2	12	13	14	0
3	1	7	0	0
4	3	2	0	0
5	110	0	0	0
6	110	111	112	0
7	12	13	14	0
8	3	8	10	0
9	0	0	0	0
10	0	0	0	0

correspond to the numbers ascribed to the parameters in Table 1. The entries exceeding 100 designate memory elements with 110, 111, and 112 identifying learning rate, course attitude, and peer attitude respectively.

From this table, for example, it can be seen that validity jeopardizing factor 8, which is selection-maturation interaction, affects the model's ability to generalize, the significance of the teacher concept on peer attitude, and the significance of the teacher concept on course attitude. These are parameters 3, 8, and 10 respectively.

Whereas Table 14 designates the attributes of the models which are to be modified, Table 15 indicates the magnitude and direction of the modification. The entries in this table have positional correspondence to those in Table 14. To illustrate

Table 15. VJFE (Effects of the factors on the parameters)

Validity jeopardizing factors	Entries			
	1	2	3	4
1	.05[a]	.05	.05	.00
2	.01	.01	.01	.00
3	.10	.10	.00	.00
4	.05	.05	.00	.00
5	.05	.00	.00	.00
6	.10	.10	.10	.00
7	.02	.02	.02	.00
8	.05	-.05[b]	.05	.00
9	.00	.00	.00	.00
10	.00	.00	.00	.00

[a]The results shown in Figure 7 were obtained by replacing this value with -.08.

[b]The results shown in Figure 7 were obtained by replacing this value with -.10.

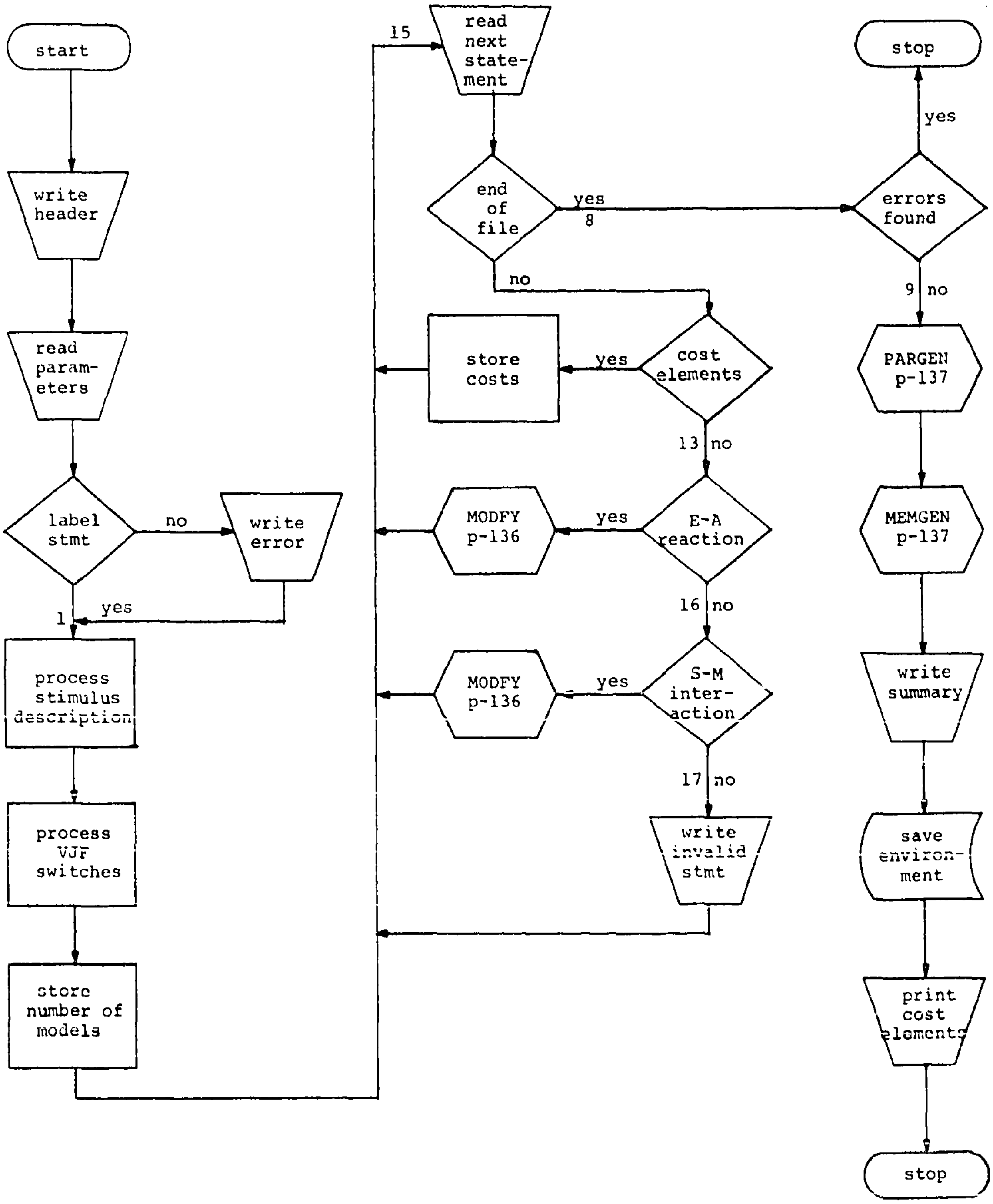
this, the previous example is extended. As a result of each activation of factor 8, the model's ability to generalize would be increased 5 percent, the significance of the teacher concept on peer attitude would be decreased 5 percent, and the significance of the teacher concept on course attitude would be increased 5 percent.

In order to alter the values in any of these tables except Table 12, one must locate the DATA statement in the Fortran program which corresponds to the table and change the appropriate elements. The elements were placed in the DATA statement by concatenating the columns of the table. IGS may be altered via data cards at the time the environment is generated.

XII. APPENDIX D: FLOW CHARTS OF PROGRAMS

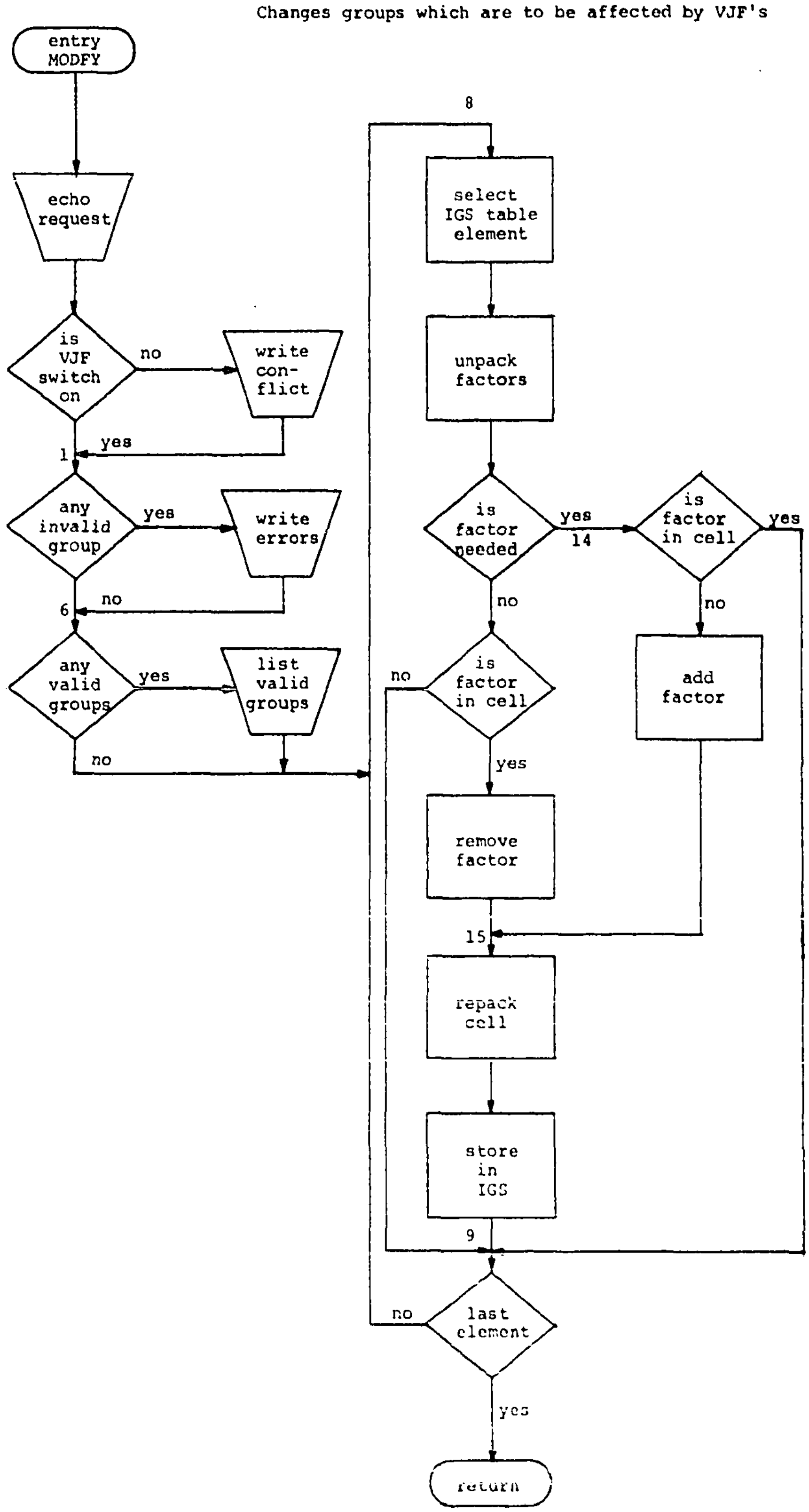
ENVIRONMENT GENERATOR

Generates experimental environment



MODFY

Changes groups which are to be affected by VJF's

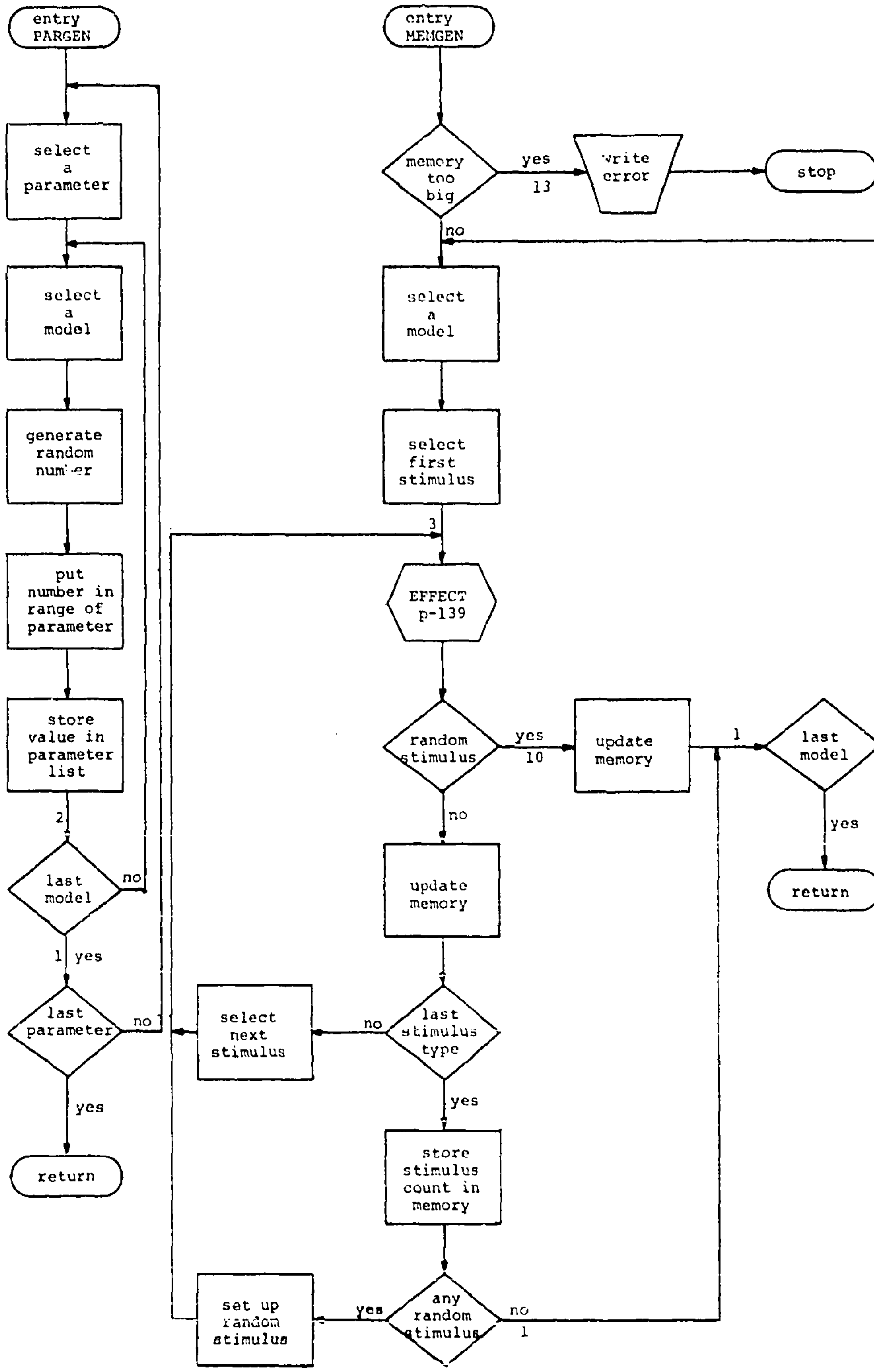


PARGEN

Generate model's parameters

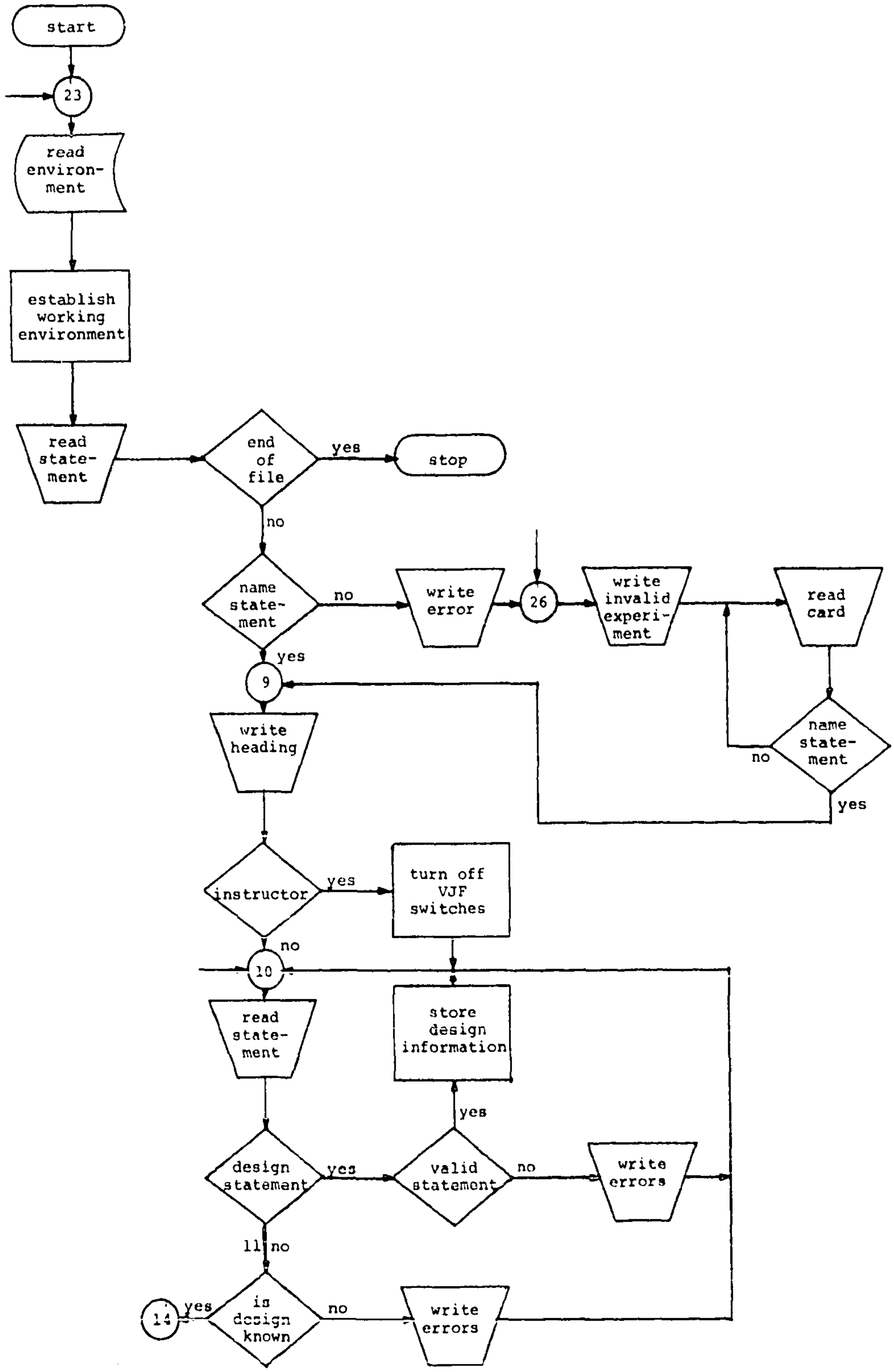
MEMGEN

Generates model's memory

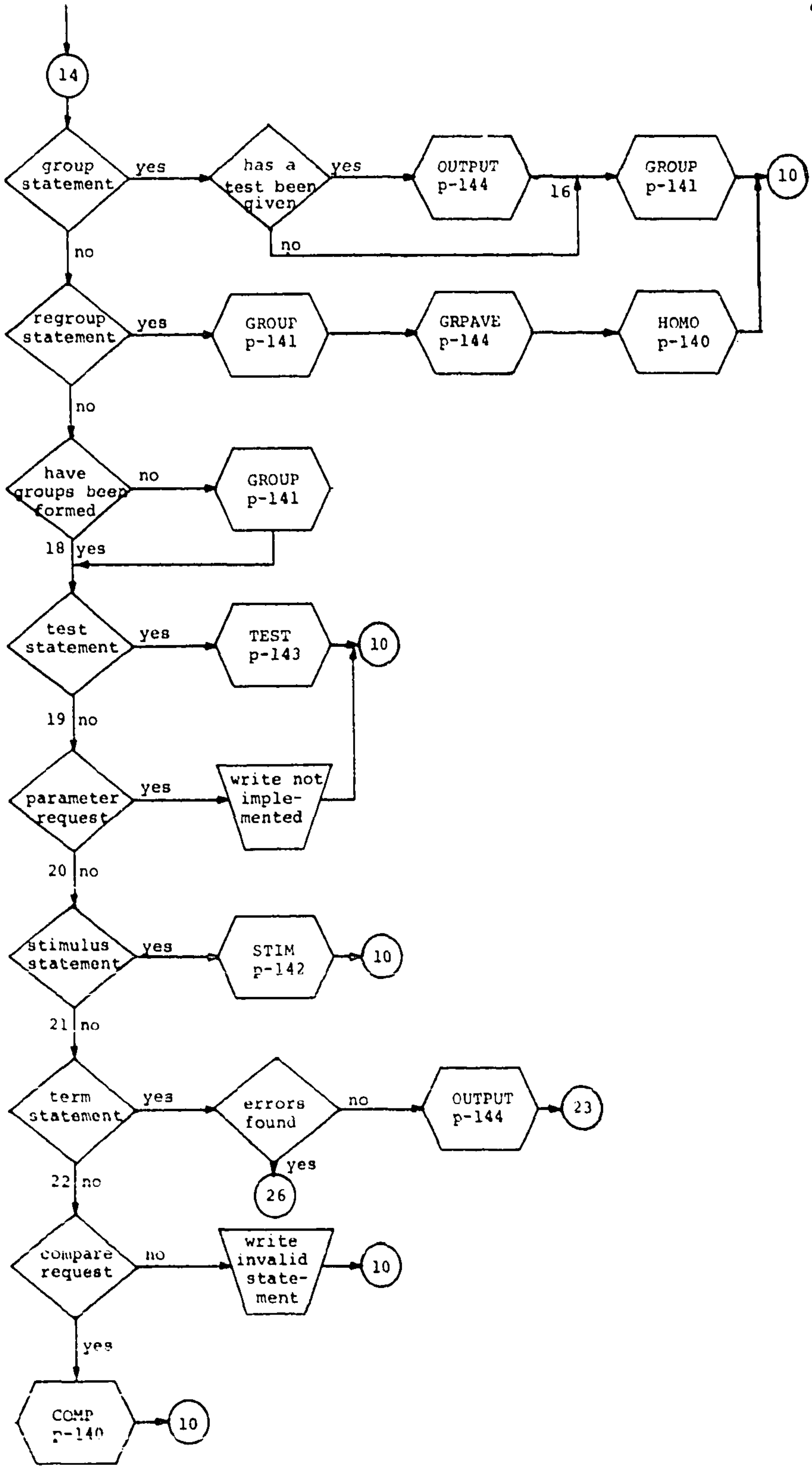


INTERPRETER

Monitor to read student's design and direct the experiment

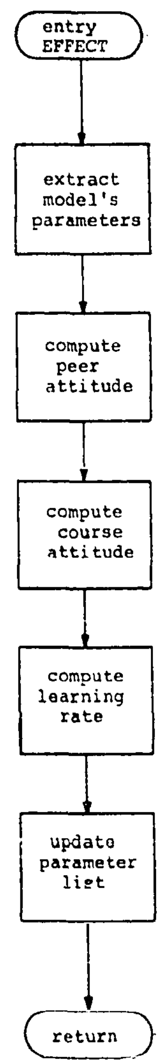


INTERPRETER - CONTINUED



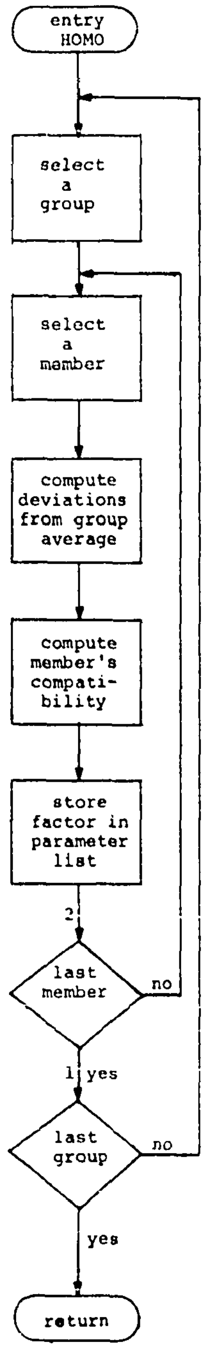
EFFECT

Computes effect of stimulus



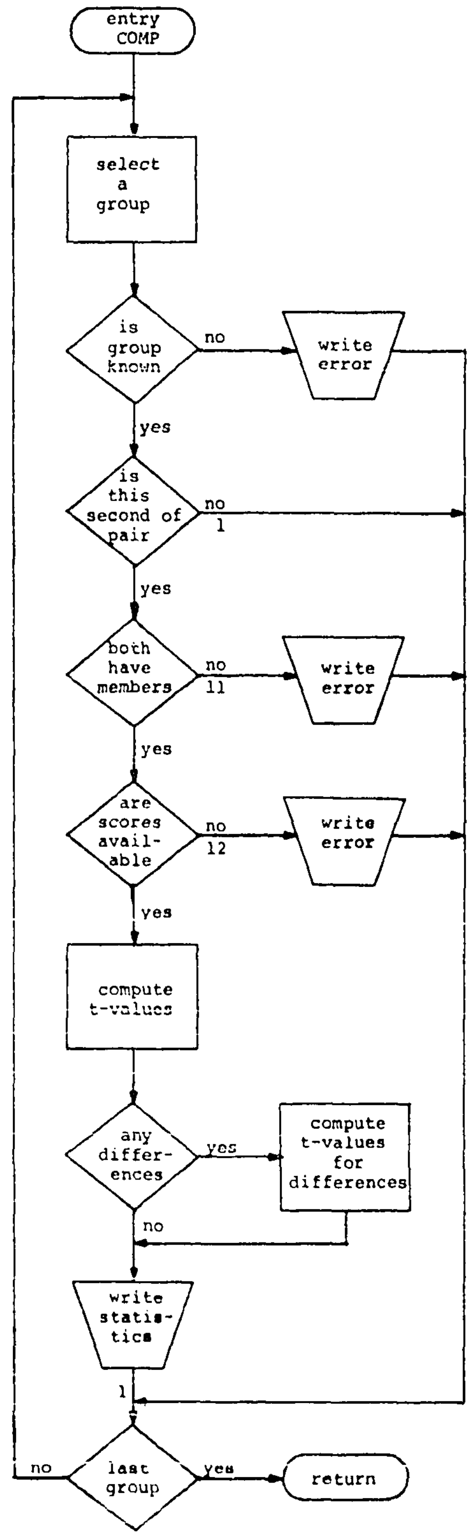
HOMO

Computes group compatibility factors



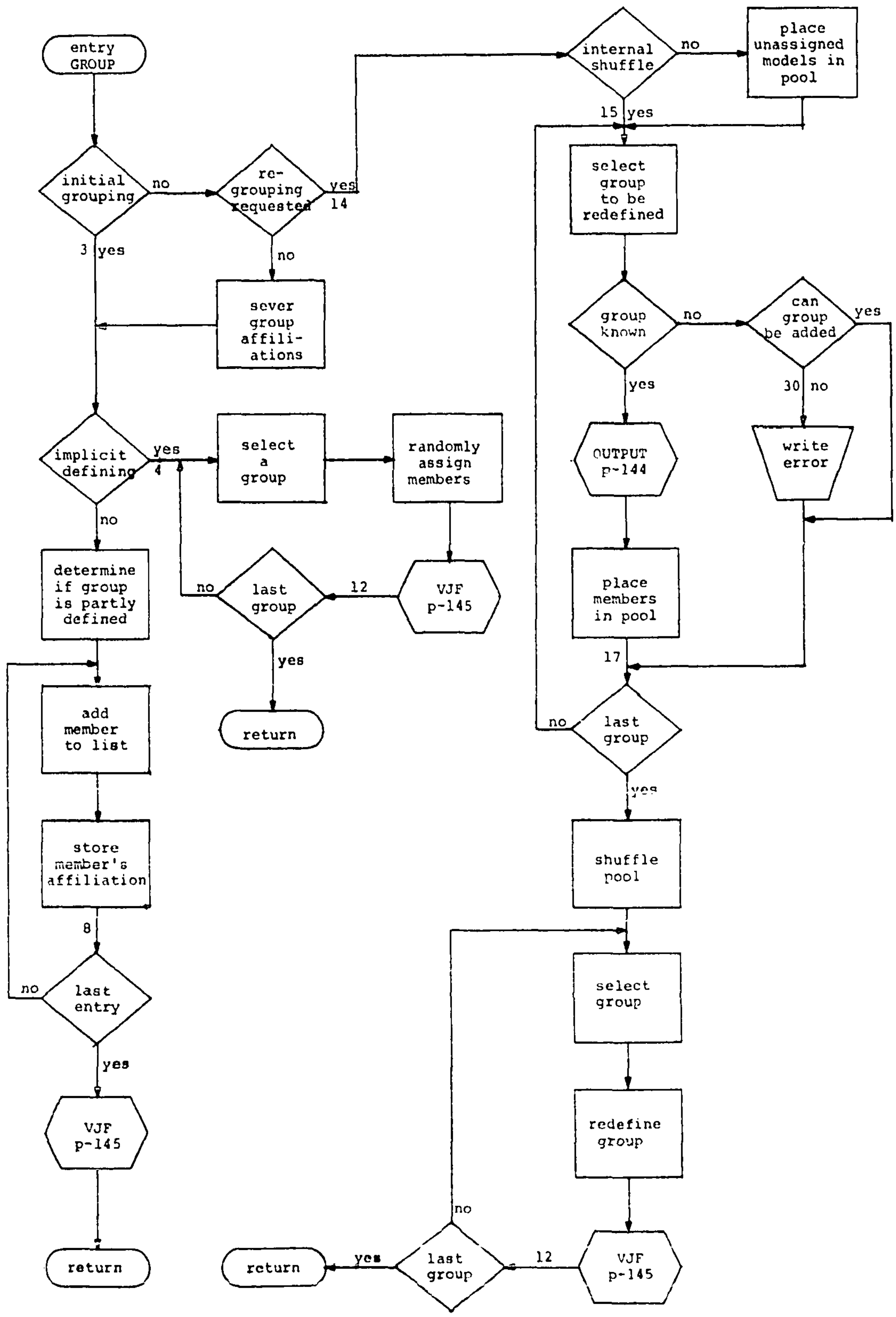
COMP

Computes t-values for comparing group behavior



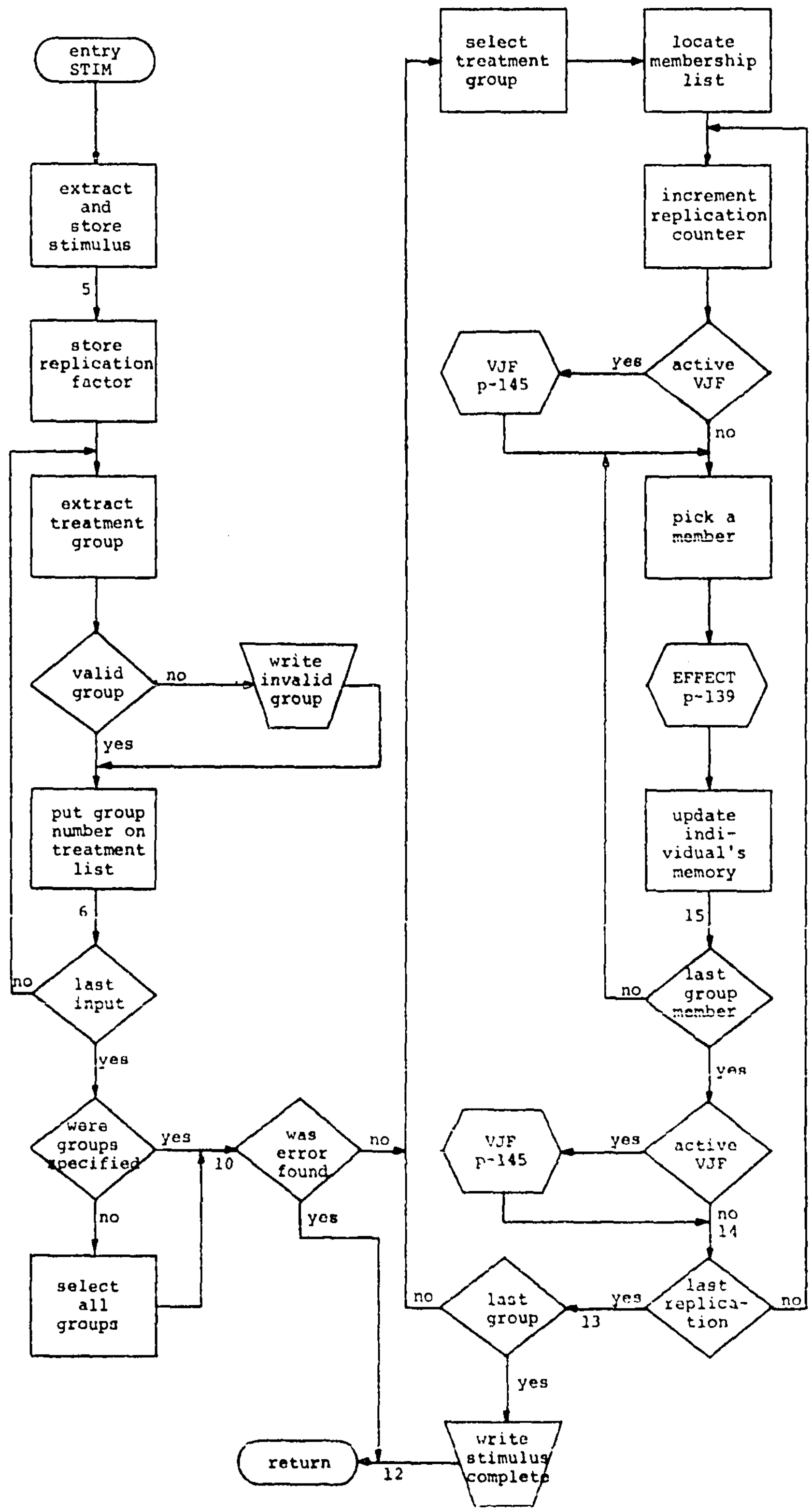
GROUP

Separates subjects into groups



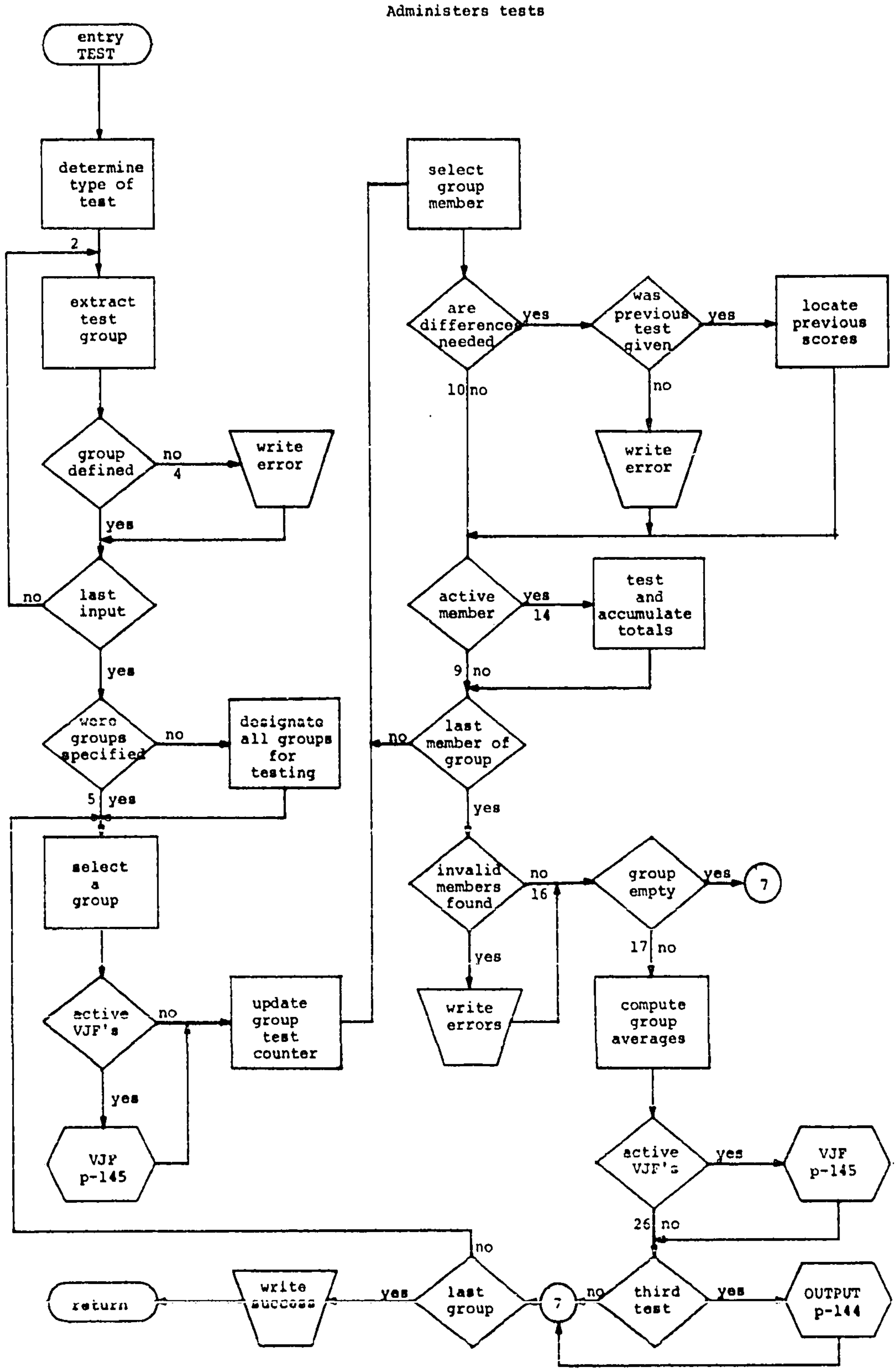
STIMULUS

Administers stimulus



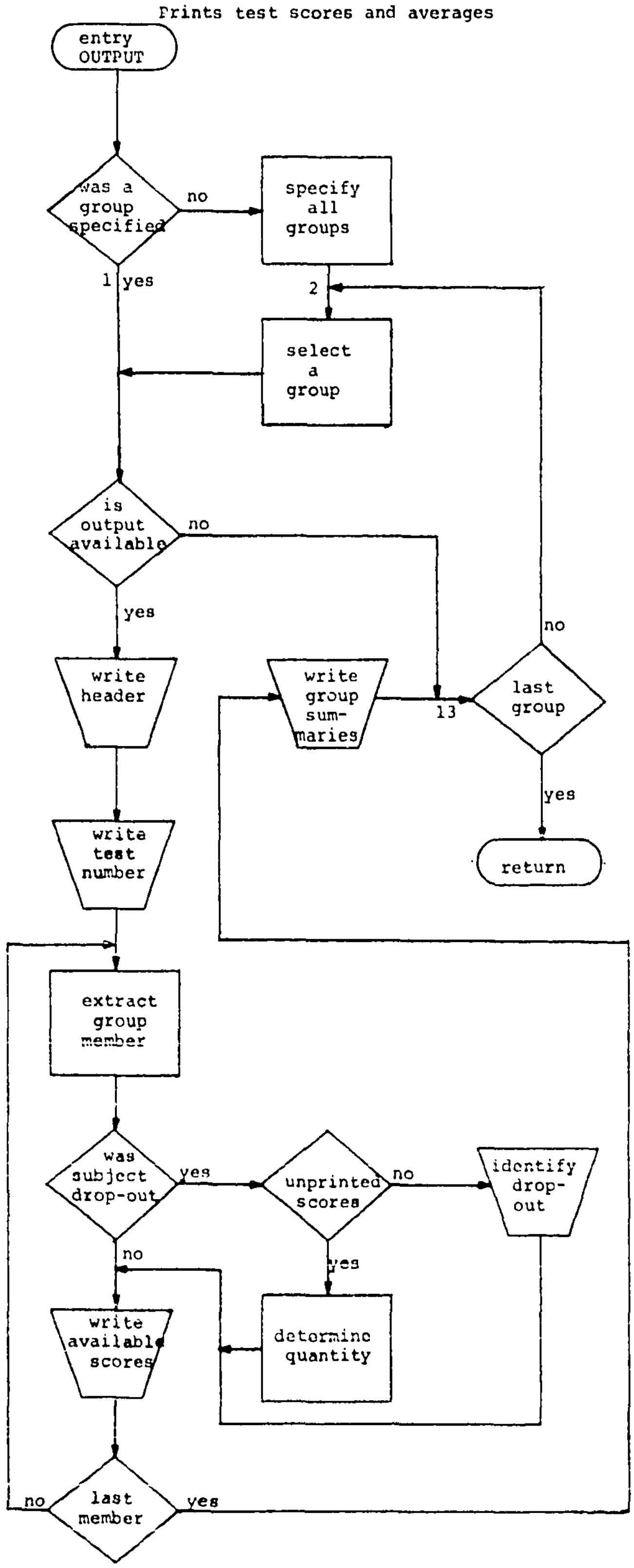
TEST

Administers tests



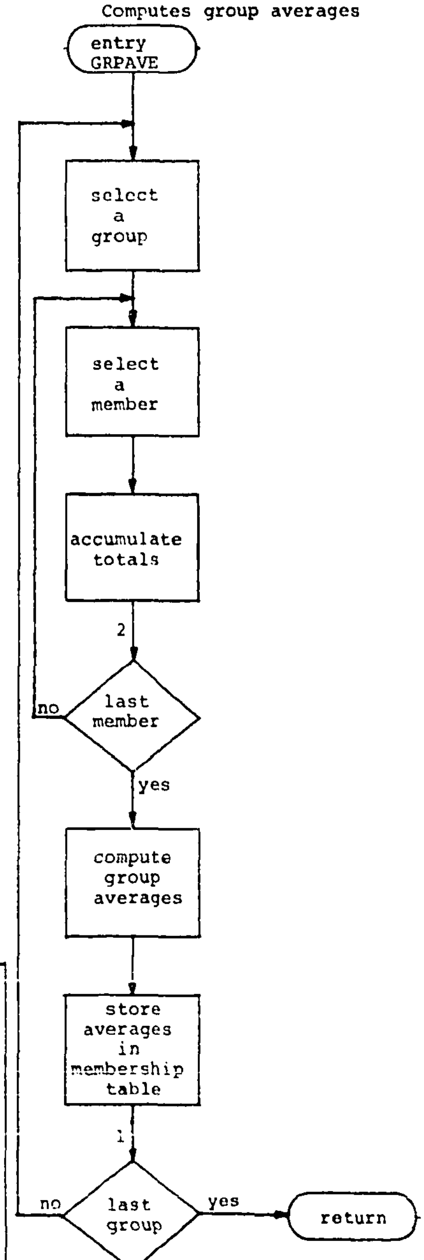
OUTPUT

Prints test scores and averages



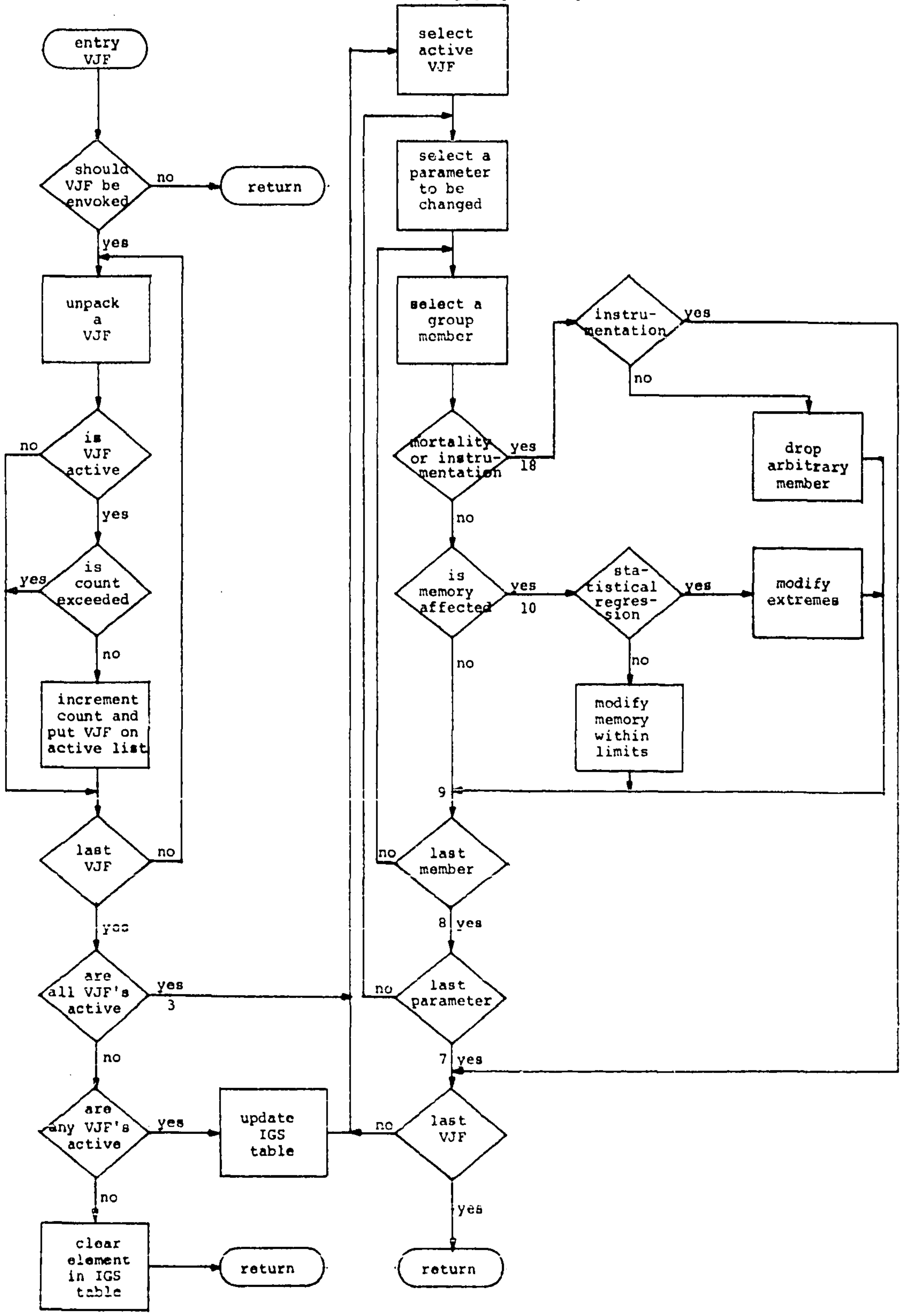
GRPAVE

Computes group averages



VJF

Administers the validity jeopardizing factors



XIII. APPENDIX E: LISTING OF COMPUTER PROGRAMS

```
C   THIS PROGRAM GENERATES THE EXPERIMENTAL ENVIRONMENT
      DIMENSION GENEFF(520),ISW(10),IVJFSW(10),IWK(10),LV(7),SP(2080)
      DIMENSION VALUE(12),IGS(12,6),COST(4)
C   GENEFF IS A MATRIX OF GENERATED SUBJECT MEMORIES.
C   IVJFSW IS A VECTOR OF VALIDITY JEOPARDIZING FACTOR SWITCHES.
C   LV IS A VECTOR OF MAXIMUM LEVELS FOR EACH DIMENSION OF THE STIMULUS.
C   SP IS A MATRIX OF SUBJECT PARAMETERS.
      DATA COMMA/','/
      DATA COST/4 *0.0/
      DATA IGS/12*28,12*0,12*3456,12*9,12*17,12*0/
      DATA IVJFSW/10*0/
      DATA JCOST/'COST'/,LEAG/'LEAG'/,LSMG/'LSMG'/
      DATA LABTST/'GPAR'/,IBLANK/' '/,IONE/'1'/,IZERO/'0'/
      LVSUM =0
      WRITE (3,96)
   96 FORMAT ('1',45X,'THE FOLLOWING ENVIRONMENT WAS GENERATED ')
      RUN =0.0
      NMEM =4
      NSP =16
      NGAVE =10
C   READ PARAMETERS OF THE ENVIRONMENT.
      READ (1,90) LABEL,NOSS,STWT,SKEW,DIQ,DLR,DAC,LV,ISW
   90 FORMAT (A4,1X,I5,5F5.0,7I1,3X,10A1)
      ICARD =1
C   VERIFY CARD LABEL.
      IF (LABEL.EQ.LABTST) GO TO 1
      WRITE (3,91) LABEL,LABTST
   91 FORMAT ('0 THE INPUT CARD IS IMPROPERLY LABELED.-COLUMNS 1 THRU 4
     1CONTAIN ',A4,' AND SHOULD CONTAIN ',A4,' RUN HAS BEEN CANCELED ')
      RUN =1.0
C   DETERMINE THE NUMBER OF DIMENSIONS OF THE STIMULUS.
    1 DO 2 I =1,6
      IF (LV(I).EQ.0) GO TO 3
```

```
      LVSUM =LV(I) +LVSUM
    2 CONTINUE
      I =7
    3 NDIMEN =I -1
      IF (NDIMEN.GT.0) GO TO 4
      WRITE (3,92)
   92 FORMAT ('0 THE INPUT CARD DOES NOT CONTAIN THE MAXIMUM LEVELS OF T
     1HE STIMULUS')
      RUN =1.0

C   COMPUTE THE NUMBER OF DISTINCT STIMULI.
    4 NTYPS =1
      DO 5 I =1,NDIMEN
    5 NTYPS =NTYPS *LV(I)

C   DETERMINE IF THE ACTIVE VALIDITY JEOPARDIZING FACTORS ARE SPECIFIED.
      DO 6 I =1,10
      IF (ISW(I).EQ.IBLANK) GO TO 6
      J =1
      IF (ISW(I).EQ.IONE) GO TO 7
      J =0
      IF (ISW(I).EQ.IZERO) GO TO 7
      WRITE (3,93) ISW(I)
   93 FORMAT ('0 ONLY ONES AND ZEROES ARE ACCEPTABLE IN THE VJF SWITCH F
     1IELD. A ',A1,' WAS FOUND AND IGNORED')
      GO TO 6
    7 IVJFSW(I) =J
    6 CONTINUE

C   CHECK TO BE SURE THE NUMBER OF SPECIFIED SUBJECTS EXCEEDS ZERO.
      IF (NOSS.GT.0) GO TO 15
      WRITE (3,94) NOSS
   94 FORMAT ('0 THE NUMBER OF SUBJECTS GENERATED MUST EXCEED ZERO.',I5,
     1' WERE REQUESTED.')
      RUN =1.0

C   READ A GROUP SELECTION OR COST CARD.
```

```
   15 READ (1,102,END= 8) LABEL,VALUE
  102 FORMAT (A4,1X,12F5.0)
      ICARD =ICARD +1
      IF (LABEL.NE.JCOST) GO TO 13
      CHECK =0.0
      DO 14 I =1,4
      CHECK =CHECK +VALUE(I)
   14 COST(I) =VALUE(I)
      IF (CHECK.NE.0.0) GO TO 15
      WRITE (3,104)
  104 FORMAT ('0',12X,'A COST CARD WAS INCLUDED WITH NO VALUES SPECIFIED
     1. -CARD WAS IGNORED.')
      GO TO 15
   13 IF (LABEL.NE.LEAG) GO TO 16

C  A GROUP SPECIFICATION CARD HAS BEEN ENCOUNTERED FOR EXPERIMENTAL
C     ARRANGEMENT REACTION.
      ICOL =1
      NVJF =2
      CALL MODFY(IGS,ICOL,NVJF,LABEL,VALUE,IVJFSW)
      GO TO 15
   16 IF (LABEL.NE.LSMG) GC TO 17

C  A GROUP SPECIFICATION CARD HAS BEEN ENCOUNTERED FOR SELECTION
C     MATURATION INTERACTION.
      ICOL =1
      NVJF =8
      CALL MODFY(IGS,ICOL,NVJF,LABEL,VALUE,IVJFSW)
      GO TO 15
   17 WRITE (3,105) LABEL,ICARD
  105 FORMAT ('0',12X,'THE LABEL ''',A4,''' ON INPUT CARD ',I3,' IS NOT
     1VALID. THE CARD WAS IGNORED.')
      GC TO 15
    8 IF (RUN.NE.1.0) GO TO 9
      WRITE (3,95)
   95 FORMAT ('0 GENERATION HAS BEEN ABORTED BECAUSE OF ERRORS PREVIOUSL
     1Y NOTED.')
```

```
      STOP
C   GENERATE SUBJECT PARAMETERS AND MEMORIES.
    9 CALL PARGEN(LV,LVSUM,NDIMEN,NOSS,NSP,NTYPS,SP)
C   CLEAR INITIAL MEMORIES.
      L =NOSS *NMEM
      DO 10 I =1,L
   10 GENEFF(I) =0.0
      CALL MEMGEN(GENEFF,SP,NOSS,LV,STWT,SKEW,NDIMEN,NTYPS,NSP,NMEM)
C   SUMMARIZE THE ENVIRONMENT.
      WRITE (3,103) NOSS
  103 FORMAT ('0',10X,I5,' SUBJECTS WERE GENERATED.')
      ISTWT =STWT
      WRITE (3,97) ISTWT
   97 FORMAT ('0',10X,I5,' STIMULI OF EACH POSSIBLE TYPE WERE ADMINISTER
     1ED TO EACH SUBJECT TO FORM HIS MEMORY.')
      ISKEW =SKEW
      WRITE (3,98) ISKEW
   98 FORMAT ('0',10X,I5,' REPLICATIONS OF A RANDOMLY CHOSEN TYPE WERE U
     1SED TO MODIFY EACH SUBJECT''S MEMORY.')
      J =NDIMEN -1
      WRITE (3,99) (LV(I),COMMA,I=1,J)
   99 FORMAT ('0',12X,'THE MAXIMUM LEVELS OF THE DIMENSIONS OF A STIMULU
     1S ARE ',9(I2,A1))
      WRITE (3,100) LV(NDIMEN),NTYPS
  100 FORMAT (' ',12X,'AND',I2,' PRODUCING ',I5,' DISTINCT TYPES OF STIM
     1ULI.')
      J =0
      DO 11 I =1,10
      IF (IVJFSW(I).EQ.0) GO TO 11
      J =J +1
      IWK(J) =I
   11 CONTINUE
C   STORE ENVIRONMENT.
```

```
      WRITE (10) GENEFF,SP,LV,IVJFSW,NOSS,NMEM,NSP,NTYPS,NGAVE,DIQ,DLR,
     1 DAC,NOIMEN,COST,IGS
      LPRT =J -1
      IF (LPRT) 18,19,20
   18 WRITE (3,107)
  107 FORMAT ('0',12X,'ALL VALIDITY JEOPARDIZING FACTORS ARE INACTIVE.')
      GO TO 21
   19 WRITE (3,101) IWK(1)
      GO TO 21
   20 WRITE (3,101) (IWK(I),COMMA,I=1,LPRT),IWK(J)
  101 FORMAT ('0',12X,'THE ACTIVE VALIDITY JEOPARDIZING FACTORS ARE ',
     1 10(I2,A1))
   21 WRITE (3,106) (COST(I),I=1,4)
  106 FORMAT ('0',12X,'THE FOLLOWING COSTS WERE ESTABLISHED FOR THIS EXP
     1ERIMENT:'/' ',15X,'THE FORMATION OF A GROUP  $',F6.2/' ',15X,'FOR
     2EACH SUBJECT USED $',F6.2/' ',15X,'TESTING COST PER SUBJECT PER TE
     3ST $',F6.2/' ',15X,'TREATMENT COST PER SUBJECT PER STIMULUS $',F6.
     4 2)
      STOP
      END


      SUBROUTINE MODFY(IGS,ICOL,NVJF,LABEL,VALUE,IVJFSW)

C  THIS PROGRAM MODIFIES THE IGS TABLE.
C  ICOL IS THE COLUMN OF IGS WHICH IS TO BE MODIFIED.
C  IGS IS THE MATRIX CONTAINING THE VALIDITY JEOPARDIZING FACTORS BY
C     GROUP BY EXPERIMENT STATUS.
C  IVJFSW IS AN ARRAY OF SWITCHES DESIGNATING ON -OFF STATUS OF VJF'S.
C  LABEL IS THE LABEL OF THE INPUT CARD REQUESTING THE MODIFICATION.
C  NVJF IS THE NUMBER OF THE VALIDITY JEOPARDIZING FACTOR WHICH IS TO
C     AFFECT ONLY SELECTED GROUPS.
C  VALUE IS THE LIST OF NUMBERS OF THE GROUPS WHICH ARE TO BE AFFECTED.
      DIMENSION IGS(12,6),IWK(12),JWK(12),NAME(9,2),VALUE(12)
      DIMENSION IVJFSW(10)
```

```
      DATA NAME/'EXPE','RIME','NTAL',' ARR','ANGE','MENT',' REA','CTIO',
     1'N','SELE','CTIO','N -M','ATUR','ATIO','N IN','TERA','CTIO','N'/

C   WRITE HEADING.
      N =1
      IF (NVJF.EQ.8) N =2
      WRITE (3,90) (NAME(I,N),I =1,9)
   90 FORMAT ('0',12X,'THE EXPLICIT GROUP SELECTION FEATURE WAS USED FOR
     1 ',8A4,A1,'.')

C   DETERMINE IF VJF IS ACTIVE.
      IF (IVJFSW(NVJF).NE.0) GO TO 1
      IVJFSW(NVJF) =1
      WRITE (3,91)
   91 FORMAT ('0',15X,'CONFLICT -THE VJF SWITCH WAS OFF BUT GROUPS WERE
     1SPECIFIED TO BE AFFECTED. -SWITCH WAS TURNED ON.')

C   CLEAR WORK VECTOR.
    1 DO 2 I =1,12
      IWK(I) =0
    2 JWK(I) =0

C   INSURE THAT SPECIFIED GROUPS ARE WITHIN RANGE.
      K =0
      DO 3 I =1,12
      J =VALUE(I)
      IF (J.GT.12) GO TO 4
      IF (J) 4,3,5

C   SAVE THE LEGAL GROUP NUMBERS.
    5 JWK(J) =NVJF
      GO TO 3

C   PUT INVALID GROUP NUMBER ON PRINT LIST.
    4 K =K +1
      IWK(K) =J
    3 CONTINUE
```

```
C   WERE INVALID GROUP NUMBERS FOUND?
       IF (K.EQ.0) GO TO 6
       LPRT =K -1
       IF (LPRT.NE.0) GO TO 19
       WRITE (3,92) IWK(1)
       GO TO 6
   19 WRITE (3,92) (IWK(I),COMMA,I=1,LPRT),IWK(K)
   92 FORMAT ('0',15X,'THE FOLLOWING INVALID GROUPS WERE SPECIFIED: ',
     1 12(I3,A1))
C   PRINT VALID NUMBERS OF GROUPS SPECIFIED.
    6 K =0
      DO 7 I=1,12
      IF (JWK(I).EQ.0) GO TO 7
      K =K +1
      IWK(K) =I
    7 CONTINUE
C   WERE VALID GROUP NUMBERS FOUND?
      IF (K.EQ.0) GO TO 8
      LPRT =K -1
      IF (LPRT.NE.0) GO TO 20
      WRITE (3,93) IWK(1)
      GO TO 8
   20 WRITE (3,93) (IWK(I),COMMA,I=1,LPRT),IWK(K)
   93 FORMAT ('0',15X,'THE FOLLOWING GROUPS WERE ACCEPTED: ',12(I3,A1))
C   MODIFY IGS TABLE.
C   ARRAY JWK CONTAINS ZEROS FOR GROUPS NOT AFFECTED.
    8 DO 9 I =1,12
C   EXTRACT THE VJF NUMBERS FROM THE ITH ROW,ICOL COLUMN OF IGS.
C      SEVERAL MAY BE PACKED IN EACH CELL.
      K =0
      L =IGS(I,ICOL)
      DO 10 J =1,10
```

```
      IF (L.EQ.0) GO TO 11
      K =K +1
      N =L
      L =L/10
   10 IWK(K) =N -L *10
C  IS THE VJF IN THIS ENTRY?
   11 N =K +1
      IWK(N) =0
      DO 12 J =1,N
      L =J
      IF (IWK(J).EQ.NVJF) GO TO 13
   12 CONTINUE

C  SHOULD THIS ENTRY CONTAIN THE VJF IN QUESTION?
   13 IF (JWK(I).NE.0) GO TO 14

C  VJF SHOULD NOT BE PRESENT. K IS NUMBER OF ELEMENTS,L POINTS TO VJF.
      IF (L.GT.K) GO TO 9

C  REMOVE VJF FROM LIST.
      IF (L.NE.K) IWK(L) =IWK(K)
      K =K -1
      GO TO 15

C  VJF SHOULD BE PRESENT.
   14 IF (L.LE.K) GO TO 9

C  ADD VJF TO LIST.
      K =K +1
      JWK(K) =NVJF

C  REPACK ENTRY.
   15 IF (K.NE.0) GO TO 18
      IGS(I,ICOL) =0
      GO TO 9
   18 IVAL =IWK(K)
   17 K =K -1
```

```
      IF (K.EQ.0) GO TO 16
      IVAL =IVAL +10 *IWK(K)
      GO TO 17
   16 IGS(I,ICOL) =IVAL
    9 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PARGEN(LV,LVSUM,NDIMEN,NOSS,NSP,NTYPS,SP)
C  THIS SUBROUTINE GENERATES THE SUBJECT'S PARAMETERS.
C  NDIMEN IS THE NUMBER OF RECOGNIZED CHARACTERISTICS OF THE STIMULUS.
C  NOSS IS THE NUMBER OF SUBJECTS.
C  NSP IS THE NUMBER OF PARAMETERS PER SUBJECT.
C  NTYPS IS THE NUMBER OF TYPES OF STIMULI.
C  MTYPS IS THE TOTAL NUMBER OF TYPES OF STIMULI.
C  SP CONTAINS THE TEMPORARY MEMORY AND THE SUBJECTS' PARAMETERS.
C  PARM 1  IQ.                                     RANGE  60 TO 140
C       2  SENSITIVITY TO PREVIOUS SUCCESS.               0.0 TO 0.5
C       3  ABILITY TO GENERALIZE.                         0.0 TO 0.5
C       4  SEX OF SUBJECT.                                 0 OR 1
C       5  SIGNIFICANCE OF CURRENT MOOD ON PEER ATT.       0 TO 1
C       6  SIGNIFICANCE OF PEER ATTITUDE ON COURSE ATT.    0 TO 1
C       7  SIGNIFICANCE OF TEACHER CONCEPT ON LEARNING.    0 TO 1
C       8  SIGNIFICANCE OF TEACHER CONCEPT ON PEER ATT.    0 TO 1
C       9  SIGNIFICANCE OF CURRENT MOOD ON COURSE ATT.     0 TO 1
C      10  SIGNIFICANCE OF TEACHER CONCEPT ON COURSE ATT.0 TO 1
C      11  PREVIOUS CHANGE IN LEARNING RATE.              -1 TO 1
C      12  PREVIOUS ATTITUDE TOWARD THE GROUP.             0 TO 100
C      13  PREVIOUS ATTITUDE TOWARD THE COURSE.            0 TO 100
C      14  PREVIOUS LEARNING RATE.                         0 TO 100
C      15  RANDOM NUMBER TO BE USED IN GENERATING MEM.
C      16  SUBJECT'S GROUP COMPATIBILITY FACTOR.           0 TO 1
      DIMENSION LV(7),SP(2080)
```

```
C  INITIALIZE RANDOM NUMBER GENERATOR
      IY =9841231

C  GENERATE PARAMETERS.
      DO 1 NPAR =1,NSP
      INDEX =NPAR -NSP

C  FOR EACH SUBJECT.
      DO 2 NSUB =1,NOSS
      INDEX =INDEX +NSP

C  GENERATE A RANDOM NUMBER.
      IY =IY *65539
      IF(IY.LT.0)IY =IY +2147483647 +1
      YFL =IY
      YFL =YFL *.4656613E-9

C  PUT PARAMETER IN PROPER RANGE.
      GO TO (3,4,4,5,6,6,6,6,6,6,7,8,8,8,9,10),NPAR

C  SET UP IQ.
    3 YFL =YFL *80.0 +60.0
      GO TO 6

C  SET UP SENSITIVITY TO SUCCESS AND ABILITY TO GENERALIZE.
    4 YFL =YFL *0.5
      GO TO 6

C  SET UP SEX
    5 I =YFL *1.999999
      SP(INDEX) =I
      GO TO 2

C  SET UP CHANGE IN LEARNING RATE
    7 YFL =(YFL -.5) *1.999999
      GO TO 6
```

```
C   SET UP ATTITUDES.
     8 YFL =YFL *100.0
       GO TO 6

C   ESTABLISH RANDCM NUMBER FOR MEMGEN.

C   GENERATE A RANDOM STIMULUS.
C     THE STIMULUS GENERATED IS FROM A NORMAL DISTRIBUTION. THUS IT IS
C     MUCH MORE LIKELY TO HAVE AVERAGE CHARACTERISTIC VALUES THAN EITHER
C     HIGH CR LOW VALUES.
     9 RANGE =LVSUM -NDIMEN
       XMEAN =(LVSUM +NDIMEN) /2.0 +.5
       VAR =(RANGE /6.0) **2
       CALL GAUSS(IY,VAR,XMEAN,V)

C   GENERATE A RANDCM NUMBER FOR THE SUM OF THE LEVELS OF THE STIMULUS.
       ISUM =V
       IF (ISUM.LT.NDIMEN) ISUM =NDIMEN +1
       IF (ISUM.GT.LVSUM) ISUM =LVSUM
C
C   RANDOMLY ASSIGN LEVELS TO THE STIMULUS.
       MAXW =ISUM-NDIMEN +1
       MAXL =MAXW
       LDO =NDIMEN -1
       LVAL =0
       MAXCO =LVSUM
       DO 11 I =1,LDO

C   INSURE THAT RESIDUE CAN BE ABSORBEC BY UNASSIGNED LEVELS.
       MAXCO =MAXCO -LV(I)
       MINVAL =ISUM -MAXCO
       IF (MINVAL.LT.1) MINVAL =1
       IF (MAXL.GT.LV(I)) MAXL =LV(I)
       CALL RANDU(IY,IX,YFL)
       IY =IX
       IVAL =(MAXL -MINVAL +.999999) *YFL +MINVAL
```

```
12 LVAL =IVAL +10 *LVAL
   MAXL =MAXW -IVAL +1
   ISUM =ISUM -IVAL
11 MAXW =MAXL
   GO TO 6
10 YFL =.5

C  SET UP MOOD,GROUP ATTITUDE,TEACHER CONCEPT OR STORE A PARAMETER.
 6 SP(INDEX) =YFL
 2 CONTINUE
 1 CONTINUE
   RETURN
   END



   SUBROUTINE MEMGEN(SUMEFF SP,NOSS,LV,STDWT,SKEW,NDIMEN,NTYPS,NSP,
  1 NMEM)

C  THIS ROUTINE GENERATES THE PERMANENT MEMORY FOR ALL SUBJECTS PRIOR
C    TO EXPERIMENTATION.
C  IV IS A WORK VECTOR USED FOR CONVERTING RANDOM INPUT INTO A STIMULUS.
C  LV IS THE VECTOR OF MAXIMUM LEVELS OF EACH STIMULUS CHARACTERISTIC.
C  NOSS IS THE NUMBER OF SUBJECTS.
C  SKEW-EACH SUBJECT HAS THIS NUMBER OF ENCOUNTERS WITH AN ARBITRARY
C    STIMULUS TO SIMULATE AN ESPECIALLY SIGNIFICANT IMPACT.
C  SP IS THE MATRIX OF SUBJECT'S PARAMETERS.
C  STDWT IS THE NUMBER OF ENCOUNTERS WITH EACH STIMULUS.
C  SUMEFF IS THE TOTAL MEMORY FOR ALL SUBJECTS (SUMMARY OF EFFECTS).
   DIMENSION C(10),IV(10),LS(10),LV(7),SP(2080),SUM(10),SUMEFF(520)
   IF(NMEM.GT.10) GO TO 13
   JMEM =NMEM -1

C  INITIALIZE IV
   K =NDIMEN -1
   IV(NDIMEN) =1
```

```
      DO 8 I=1,K
      J =NDIMEN-I
    8 IV(J)=IV(J+1) *LV(J+1)
      INDEX =0
C   GENERATE MEMORY FOR ALL SUBJECTS
      MPTR =1-NMEM
      DO 1 I=1,NOSS
C   EXTRACT THE RANDOM STIMULI
      NUMB =SP(NSP*I -1)
      INDEX =INDEX +1
      MPTR =MPTR +NMEM
      DO 11 K=1,JMEM
   11 SUMEFF(MPTR+K) =50.0
C   SET SWITCH SIGNIFYING THAT THIS ISNT THE LAST STIMULI FOR THE SUBJECT
      LAST =0
      DO 12 NEFF =1,JMEM
   12  SUM(NEFF) =0.0
C   INITIALIZE STIMULUS VECTOR.
      DO 2 K=1,NDIMEN
    2 LS(K) =1
C   COMPUTE THE IMMEDIATE EFFECT OF THIS STIMULUS.
    3 CALL EFFECT(SUMEFF,MPTR,SP,LS,LV,INDEX,NSP,C)
C   SAVE THE RESULTS.
      IF(LAST.EQ.1) GO TO10
      DO 14 NEFF =1,JMEM
   14 SUM(NEFF) =SUM(NEFF) +C(NEFF)
C   PROCESS EVERY STIMULUS TYPE.
      DO 4 K=1,NDIMEN
C   IF KTH STIMULUS HAS REACHED MAXIMUM TRY NEXT.
```

```
      IF(LS(K).EQ.LV(K)) GO TO 4
C   INCREASE NON-MAXIMUM STIMULUS.
      LS(K) =LS(K) +1
C   IF THIS ISNT LOWEST LEVEL STIMULUS REINITIALIZE LOWER STIMULI.
      IF(K.EQ.1) GO TO3
      L =K-1
      DO 5 J=1,L
    5 LS(J) =1
      GO TO 3
    4 CONTINUE
      FNTYPS =NTYPS
      WT =STDWT *FNTYPS
C   SET MEMORY TO NORMAL GENERATED STATE.
      SUMEFF(MPTR) =WT
      DO 15 NEFF =1,JMEM
   15 SUMEFF(MPTR +NEFF) =SUM(NEFF) /FNTYPS
C   IS SKEW TO BE APPLIED?
      IF(SKEW.EQ.0.) GO TO1
      LAST =1
C   UNPACK RANDOM STIMULUS
      IX =NDIMEN +1
      DO 7 K =1,NDIMEN
      IX =IX -1
      INUMB =NUMB /10
      LS(IX) =NUMB -INUMB *10
    7 NUMB =INUMB
      GO TO 3
C   MODIFY MEMORY BY RANDOM STIMULUS.
   10 TWT =SUMEFF(MPTR) +SKEW
      SUMEFF(MPTR) =TWT
      DO 16 NEFF =1,JMEM
```

```
      K =MPTR +NEFF
   16 SUMEFF(K) =(SUMEFF(K)*WT +C(NEFF)*SKEW)/TWT
    1 CONTINUE
      RETURN
   13 WRITE (3,99)
   99 FORMAT('0   THE DIMENSIONS OF IV & SUM MUST BE NMEM OR MORE IN SUB
     'ROUTINE MEMGEN')
      STOP
      END


      SUBROUTINE EFFECT(SUMEFF,MPTR,SP,LS,LV,INDEX,NSP,C)

C  THIS ROUTINE COMPUTES THE EFFECT OF A STIMULUS ON THE SUBJECT.
      DIMENSION C(10),LS(10),LV(7),SP(2080),SUMEFF(520)

C  ALL VARIABLES BEGINNING WITH P ARE SUBJECT'S PARAMETERS.
C  C IS A VECTOR OF COMPUTED EFFECTS  LR,AC AND AG
C  INDEX IS THE SUBJECT'S NUMBER.
C  LS IS THE STIMULUS VECTOR.
C  LV IS THE VECTOR OF MAXIMUM LEVELS OF EACH STIMULUS CHARACTERISTIC.
C  MPTR IS THE POINTER TO THE MEMORY ELEMENTS OF THIS SUBJECT.
C  NSP IS THE NUMBER OF PARAMETERS FOR EACH SUBJECT.
C  SP IS THE MATRIX OF SUBJECT PARAMETERS AND TEMPORARY STORAGE.
C  SUMEFF IS THE TOTAL MEMORY FOR ALL SUBJECTS (SUMMARY OF EFFECTS).
      I =(INDEX-1) *NSP

C  EXTRACT THIS SUBJECT'S PARAMETERS.
      PIQ =SP(I+1)
      PPS =SP(I+2)
      PGEN =SP(I+3)
      PSEX =SP(I+4)
      PMPA =SP(I+5)
      PPACA =SP(I+6)
      PTL =SP(I+7)
```

```
      PTPA =SP(I+8)
      PMCA =SP(I+9)
      PTCA =SP(I+10)
      PCLR =SP(I+11)
      PGA =SP(I+12)
      PCA =SP(I+13)
      PC =SP(I+NSP)
      XMLR =SUMEFF(MPTR +1)
      XMCA =SUMEFF(MPTR +2)
      XMPA =SUMEFF(MPTR +3)
C   COMPUTE SUBJECT'S ATTITUDE TOWARD THE GROUP.
      TCHAR1 =LV(1)
C     COMPUTE ADJUSTED TEACHER'S WARMTH AND SUBJECT'S PREVIOUS MOOD.
      ADJTW =(LS(1) /TCHAR1 -1.0/(2.0 *TCHAR1))*100.0
      ADJPM =.5 *(PGA +PCA)
      C(3) =(PC *100.0 +ADJTW*PTPA +ADJPM*PMPA)/(1.0 +PTPA +PMPA)
     1  *(1.0 -PGEN) +PGEN *XMPA
C   COMPUTE COURSE ATTITUDE FOR THIS STIMULUS.
      XL3 =LV(3)
C     COMPUTE ADJUSTED TEACHER'S ATTITUDE TOWARDS THE COURSE
      ADJTAC =(LS(3) /XL3-1.0  /(2.0 *XL3))*100.0
      WAC =((ADJTAC*PMCA +C(3)*PPACA +ADJPM*PTCA +PGEN*XMCA)
     1 /(PMCA +PPACA +PTCA +PGEN)) /100.0
      C(2) =((WAC *(PCLR +1.0)*PPS) /((2.0 *WAC -1.0)*PCLR +1.0)
     1  +(WAC *(1.0 -PPS))) *100.0
C   COMPUTE LEARNING RATE
      XL2 =LV(2)
C     COMPUTE ADJUSTED TEACHER'S ACADEMIC RECORD.
      ADJTAR =(LS(2) /XL2-1.0/(2.0*XL2))*100.0
      XLR =((C(2) *.5 + ADJTAR *PTL +XMLR*PGEN*PIQ/100.0)
     1 /(0.5 +PTL +PGEN *PIQ/100.0))
```

```
      AVSTIM =(LV(1) +1.0)/2.0
      AF =((LS(1) -AVSTIM) /(LV(1) -AVSTIM)) *((140.0 -PIQ)/80.0)
      YLR =(XLR *(AF +1.0))/(.02 *XLR *AF -AF +1.0)
      C(1) =XLR *(1.0 -PTL) +PTL *YLR
C   SAVE VALUES COMPUTED AND COMPUTE CHANGE IN LEARNING RATE.
      SP(I +11) =(C(1) -SP(I +14))/100.0
      SP(I +14) =C(1)
      SP(I +13) =C(2)
      SP(I +12) =C(3)
      RETURN
      END
```

```
C  MONOTCT PROGRAM FOR THE EXPERIMENT.
      COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
     1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KOEXP,LGNEQ,
     2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
     3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
     4TSCOST

C COST IS AN ARRAY CONTAINING COMPONENTS OF COST FOR THE EXPERIMENT.
C     C(1) IS THE COST OF FORMING A GROUP.
C     C(2) IS THE COST ASSOCIATED WITH ACQUIRING EACH SUBJECT.
C     C(3) IS THE TESTING COST PER TEST PER SUBJECT.
C     C(4) IS THE COST OF ADMINISTERING A STIMULUS TO A SUBJECT.
C  IGPIS IS 1 IF INDIVIDUAL TEST SCORES ARE REQUESTED.
C  IGS IS THE MATRIX CONTAINING VALIDITY JEOPARDIZING FACTORS BY GROUP
C     BY EXPERIMENT STATUS.
C  IGSW IS A WORKING COPY OF IGS.
C  IRAND IS AN ARRAY OF RANDOM NUMBERS.
C  IVJFG CONTAINS THE MAXIMUM VJF ENVOCATIONS FOR EACH GROUP.
C  IVJFGW IS A WORKING COPY OF IVJFG.
C  IVJFP CONTAINS THE NUMBER OF THE PARAMETERS AFFECTED BY EACH VJF.
C  IVJFSW IS A VECTOR OF SWITCHES FOR THE VJFS (ON =1,OFF =0).
C  LTS IS VECTOR OF POINTERS TO THE SUBJECT'S LAST TEST SCORE.
C  NTST IS A VECTOR OF THE NUMBER OF TESTS GIVEN EACH GROUP.
C  SP IS A VECTOR OF SUBJECT PARAMETERS.
C  SUMEFF IS A MATRIX OF WORKING SUBJECT MEMORIES.
C  TSCORE IS A MATRIX OF TEST SCORES BY SUBJECT.
C  VJFE CONTAINS THE PERCENT A PARAMETER IS TO CHANGE AS A RESULT OF
C     AN ENVOKED VJF.
      DIMENSION C(3),IGS(12,6),IHOMO(12),INPT(25),INPW(25),
     1IRAND(131),IVJFG(10,12),IVJFP(10,4),IVJFSW(10),
     2LS(7),LV(7),NSGACT(12),VJFE(10,4)
      DATA IVJFP /5,12,1,3,110,110,12,3,0,0,6,13,7,2,0,111,13,8,0,0,9,
     1 14,0,0,0,112,14,10,0,0,10*0/
      DATA VJFE /.05,.01,.10,.05,.05,.10,.02,.05,.0,.0,.05,.01,.10,
     1 .05,.0,.10,.02,-.05,.0,.0,.05,.01,3*.0,.10,.02,.05,12*.0/
      DATA IDGP /'GRUP'/,IDSTIM/'STIM'/,IDPARM/'PARM'/,IDTEST/'TEST'/,
     1 IDTERM/'TERM'/,IDDSGN/'DSGN'/,IDNAME/'NAME'/,IDRGRP/'RGRP'/,
```

```
     2  ICOMP/'COMP'/
      DATA IVJFG/50,9,50,50,50,9,50,50,1,1,50,9,50,50,50,9,50,50,1,1
     1          ,50,9,50,50,50,9,50,50,1,1,50,9,50,50,50,9,50,50,1,1
     2          ,50,9,50,50,50,9,50,50,1,1,50,9,50,50,50,9,50,50,1,1
     3          ,50,9,50,50,50,9,50,50,1,1,50,9,50,50,50,9,50,50,1,1
     4          ,50,9,50,50,50,9,50,50,1,1,50,9,50,50,50,9,50,50,1,1
     5          ,50,9,50,50,50,9,50,50,1,1,50,9,50,50,50,9,50,50,1,1/
      DATA INST/'INST'/,IOFF/'OFF '/
      WRITE (3,103)
  103 FORMAT ('1')
      DO 25 I =1,25
   25 INPW(I) =0
   23 NSG =0

C  RETRIEVE THE EXPERIMENTAL ENVIRONMENT.
      READ  (10) SUMEFF,SP,LV,IVJFSW,NOSS,NMEM,NSP,NTYPS,NGAVE,DIQ,DLR,
     1 DAC,NDIMEN,COST,IGS
      REWIND 10
      KOEXP =0
      LGNEQ =0
      IY =879351

C  FORM AN ARRAY OF RANDOM NUMBERS BETWEEN 1 AND NOSS TO BE USED FOR
C     GROUPING AND REGROUPING SUBJECTS.
      DO 40 I =1,NOSS
      ISGN(I) =0
      IY =IY *65539
      IF (IY.LT.0) IY =IY +2147483647 +1
      YFL =IY
      YFL =YFL *.4656613E-9
      NUMT =YFL *NOSS +1
      IF (NUMT.GT.NOSS) NUMT =NOSS
   40 IRAND(I) =NUMT

C  PLACE A SPARE RANDOM INTEGER IN THE LAST POSITION OF LIST.
      IRAND(NOSS +1) =IY
      TSCOST =0.0
```

```
C   TRANSFER DATA TC WORKING TABLES.
      DO 2 I=1,12
      DO 2 J =1,6
    2 IGSW(I,J) =IGS(I,J)
      DO 3 I =1,10
      IF(IVJFSW(I).NE.0) GCTO5
      DO 4 J =1,12
    4 IVJFGW(I,J) =0
      GO TO 3
    5 DO 6 J =1,12
    6 IVJFGW(I,J) =IVJFG(I,J)
    3 CONTINUE
      IPS =0
      DO 7 I =1,12
      NSGR(I) =0
      IGNEQ(I) =0
      NSGACT(I) =0

C   SET NUMBER OF TESTS ON EACH GROUP TO ZERO.
      NTST(I) =0
    7 NTSTT(I) =0
      DO 8 I =1,NOSS
      LTS(I) =0

C   INITIALIZE TEST SCORES.
      DO 8 J =1,9
    8 TSCORE(J,I) =-1.0
      ICARD =0

C   READ NAME STATEMENT CARD.
      READ (1,90,END=999) IDENT,(INPT(J),J=1,18)
   90 FORMAT (19A4)
      ICARD =ICARD +1
      IF (IDENT.EQ.IDNAME) GO TO 9
      WRITE (3,91)
   91 FORMAT ('0 THE FIRST CARD IS NOT A NAME CARD. ALL INPUT PRECEEDING
```

```
     1 A VALID NAME CARD WILL BE FLUSHED.')
      WRITE (3,101)   IDENT,(INPT(J),J=1,18)
  101 FORMAT ('0 THE CARD IMAGE IS ''',19A4,'''')
      GO TO 26
    9 WRITE (3,92)(INPT(J),J =1,18)
   92 FORMAT ('0',35X,'EXPERIMENTER -',18A4)
      IF (INPT(1).NE.INST) GO TO 30
      IF (INPT(18).NE.IOFF) GO TO 30

C  TURN OFF VALIDITY JEOPARDIZING FACTORS.
      DO 29 I =1,10
      DO 32 J =1,12
   32 IVJFGW(I,J) =IVJFG(I,J)
   29 IVJFSW(I) =0
      GO TO 10
   30 DO 33 I =1,10
      DO 33 J =1,12
   33 IVJFGW(I,J) =IVJFG(I,J)

C  READ OTHER STATEMEMT CARDS.
   10 READ (1,93,END=999) IDENT,(INPT(J),J=1,24)
   93 FORMAT (A4,24I3)
      ICARD =ICARD +1

C  IS THIS A DESIGN CARD?
      IF (IDENT.NE.IDDSGN) GO TO 11
      IPS =0
      NG =INPT(1)
      NSG =INPT(2)
      IGPIS =INPT(3)
      INPW(2) =NG
      INPW(3) =NSG
      DO 12 I =1,12
   12 NSGR(I) =0
      IF (NG.GT.12) GO TO 13
      J =NG *NSG
      IF(J.EQ.0) GO TO 13
```

```
      IF(J.GT.NOSS) GO TO 13
      GO TO 10
   13 WRITE (3,94) ICARD,NOSS
   94 FORMAT ('0 DSGN CARD',I4,' IS FAULTY. IT MUST CONTAIN THE NUMBER O
     1F GROUPS,NUMBER OF SUBJECTS PER GROUP,AND THEIR PRODUCT MUST BE LE
     2SS THAN ',I3)
      KOEXP =1
      GO TO 10
   11 IF(ICARD.NE.2) GO TO 14
      WRITE (3,95)
   95 FORMAT ('0 DSGN CARD IS MISSING OR OUT OF ORDER')
      KOEXP =1
      NG =4
      NSG =25

C  IS THIS A GROUP CARD?
   14 IF (IDENT.NE.IDGP) GO TO 151

C  NOTE: ANY TIME A GRUP FUNCTION IS ENCOUNTERED AFTER A STIM,RGRP,TEST
C     OR PARM FUNCTION HAS BEEN PROCESSED IT WILL CLEAR ALL PREVIOUS
C     GROUPINGS.

C  HAVE THE GROUPS BEEN DEFINED?
      IF (IPS.NE.2) GO TO 16
      NOGP =-5

C  WRITE OUT PREVIOUS TOTALS.
      IF (KOEXP.EQ.1) GO TO 10
      CALL OUTPT(NOGP)
   16 CALL GROUP(INPT,IRAND,IVJFP,IVJFSW,VJFE)
      IPS =1
      GO TO 10

C  IS THIS A REGROUPING REQUEST?
  151 IF (IDENT.NE.IDRGRP) GO TO 15

C DETERMINE IF THIS IS A SHUFFLE OR NEW GROUP SELECTION.
```

```
      IPS =4
      IF (INPT(1).EQ.1) IPS =3
      CALL GROUP(INPT,IRAND,IVJFP,IVJFSW,VJFE)
      IPS =2
      IF (KOEXP.EQ.1) GO TO 10
      CALL GRPAVE
      CALL HOMO(DIQ,DLR,DAC)
      GO TO 10
   15 IF (IPS.EQ.2) GO TO 18
      IF (IPS.NE.0) GO TO 17
      CALL GROUP(INPW,IRAND,IVJFP,IVJFSW,VJFE)
   17 IPS =2
      IF (KOEXP.EQ.1) GO TO 18
      CALL GRPAVE
      CALL HOMO(DIQ,DLR,DAC)

C     IS THIS A TEST REQUEST?
   18 IF (IDENT.NE.IDTEST) GO TO 19
      CALL TEST (INPT,IVJFP,IVJFSW,NSGACT,VJFE)
      GO TO 10

C     IS THIS A REQUEST FOR PARAMETER VALUES?
   19 IF (IDENT.NE.IDPARM) GO TO 20
      WRITE (3,96)
   96 FORMAT ('0  PARAMETERS NOT AVAILABLE YET')
      GO TO 10

C     IS THIS A STIMULUS REQUEST?
   20 IF (IDENT.NE.IDSTIM) GO TO 21
      CALL STIM(C,INPT,IVJFP,IVJFSW,LV,NDIMEN,VJFE)
      GO TO 10

C     IS THIS THE END OF THE EXPERIMENT?
   21 IF(IDENT.NE.IDTERM) GO TO 22
      K =0
      IF (KOEXP.EQ.1) GO TO 26
      DO 34 J =1,NOSS
```

```
      IF (LTS(J).NE.0) K =K +1
   34 CONTINUE
      TSCOST =TSCOST +K *COST(2)
      IF (TSCOST.LT..001) GO TO 41
      WRITE (3,102) TSCOST
  102 FORMAT ('0 THE ESTIMATED COST OF THE EXPERIMENT IS',F12.2)
   41 NOGP =-5
      CALL OUTPT(NOGP)
      WRITE (3,103)
      GO TO 23
   22 IF (IDENT.NE.ICOMP) GO TO 222
      IF (KOEXP.EQ.1) GO TO 10
      CALL COMP (INPT,NSGACT)
      GO TO 10
  222 WRITE (3,97) ICARD,IDENT
   97 FORMAT ('0 THE FIRST FOUR COLUMNS OF EXPERIMENTAL DESCRIPTER CARD'
     1,I4,' CONTAINS ',I4,' WHICH IS NOT A VALID IDENTIFIER. THIS CARD H
     2AS BEEN SKIPPED.')
      KOEXP =1
      GO TO 10
   26 WRITE(3,99)
   99 FORMAT ('0  DUE TO ERRORS PREVIOUSLY ENCOUNTERED EXP HAS BEEN SKIP
     1PED')
      WRITE (3,103)
   27 READ (1,98,END=999) IDENT,(INPT(J),J=1,18)
   98 FORMAT (19A4)
      ICARD =1
      IF (IDENT.EQ.IDNAME) GO TO 9
      GO TO 27
  999 STOP
      END



      SUBROUTINE EFFECT(C,INDEX,LS,LV,MPTR)
```

```
C   THIS ROUTINE COMPUTES THE EFFECT OF A STIMULUS ON THE SUBJECT.
      COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
     1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KOEXP,LGNEQ,
     2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
     3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
     4TSCOST
      DIMENSION C(1),LS(1),LV(1)

C   ALL VARIABLES BEGINNING WITH P ARE SUBJECT'S PARAMETERS.
C   C IS A VECTOR OF COMPUTED EFFECTS LR,AC,AG.
C   INDEX IS THE SUBJECT'S NUMBER.
C   LS IS THE STIMULUS VECTOR.
C   LV IS THE VECTOR OF MAXIMUM LEVELS OF EACH STIMULUS CHARACTERISTIC.
C   MPTR IS THE POINTER TO THE MEMORY ELEMENTS OF THIS SUBJECT.
C   NSP IS THE NUMBER OF PARAMETERS FOR EACH SUBJECT.
C   SP IS THE MATRIX OF SUBJECT PARAMETERS AND TEMPORARY STORAGE.
C   SUMEFF IS THE TOTAL MEMORY FOR ALL SUBJECTS (SUMMARY OF EFFECTS).
      I =(INDEX-1) *NSP

C   EXTRACT THIS SUBJECT'S PARAMETERS.
      PIQ =SP(I+1)
      PPS =SP(I+2)
      PGEN =SP(I+3)
      PSEX =SP(I+4)
      PMPA =SP(I+5)
      PPACA =SP(I+6)
      PTL =SP(I+7)
      PTPA =SP(I+8)
      PMCA =SP(I+9)
      PTCA =SP(I+10)
      PCLR =SP(I+11)
      PGA =SP(I+12)
      PCA =SP(I+13)
      PC =SP(I+NSP)
      XMLR =SUMEFF(MPTR +1)
      XMCA =SUMEFF(MPTR +2)
      XMPA =SUMEFF(MPTR +3)
```

```
C  COMPUTE SUBJECT'S ATTITUDE TOWARD THE GROUP.
      TCHAR1 =LV(1)

C     COMPUTE ADJUSTED TEACHER'S WARMTH AND SUBJECT'S PREVIOUS MOOD.
      ADJTW =(LS(1) /TCHAR1 -1.0/(2.0 *TCHAR1))*100.0
      ADJPM =.5 *(PGA +PCA)
      C(3) =(PC *100.0 +ADJTW*PTPA +ADJPM*PMPA)/(1.0 +PTPA +PMPA)
     1  *(1.0 -PGEN) +PGEN *XMPA

C  COMPUTE COURSE ATTITUDE FOR THIS STIMULUS.
      XL3 =LV(3)

C     COMPUTE ADJUSTED TEACHER'S ATTITUDE TOWARDS THE COURSE
      ADJTAC =(LS(3) /XL3-1.0  /(2.0 *XL3))*100.0
      WAC =((ADJTAC*PMCA +C(3)*PPACA +ADJPM*PTCA +PGEN*XMCA)
     1 /(PMCA +PPACA +PTCA +PGEN)) /100.0
      C(2) =((WAC *(PCLR +1.0)*PPS) /((2.0 *WAC -1.0)*PCLR +1.0)
     1  +(WAC *(1.0 -PPS))) *100.0

C  COMPUTE LEARNING RATE
      XL2 =LV(2)

C     COMPUTE ADJUSTED TEACHER'S ACADEMIC RECORD.
      ADJTAR =(LS(2) /XL2-1.0/(2.0*XL2))*100.0
      XLR =((C(2) *.5 + ADJTAR *PTL +XMLR*PGEN*PIQ/100.0)
     1 /(0.5 +PTL +PGEN *PIQ/100.0))
      AVSTIM =(LV(1) +1.0)/2.0
      AF =((LS(1) -AVSTIM) /(LV(1) -AVSTIM)) *((140.0 -PIQ)/80.0)
      YLR =(XLR *(AF +1.0))/(.02 *XLR *AF -AF +1.0)
      C(1) =XLR *(1.0 -PTL) +PTL *YLR

C  SAVE VALUES COMPUTED AND COMPUTE CHANGE IN LEARNING RATE.
      SP(I +11) =(C(1) -SP(I +14))/100.0
      SP(I +14) =C(1)
      SP(I +13) =C(2)
      SP(I +12) =C(3)
```

```
      RETURN
      END


      SUBROUTINE HOMO(DIQ,DLR,DAC)
C   THIS ROUTINE COMPUTES THE HOMOGENIETY FACTOR FOR EACH SUBJECT IN EACH
C   GROUP AND TUCKS THE VALUE IN THE LAST POSITION OF THE SUBJECT'S
C   PARAMETER MATRIX.
      COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
     1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KOEXP,LGNEQ,
     2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
     3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
     4TSCOST
      DIMENSION WACDI(5),WACI(6),WIQDI(5),WIQI(6),WLRDI(5),WLRI(6)
      EQUIVALENCE (WIQDI,WLRDI,WACDI),(WIQI,WLRI,WACI)
      DATA WIQDI/2.,.5,0.,-1.,-3./,WIQI/-4.,-1.,1.,2.,-1.,-4./

C   PROCESS ALL GROUPS.
      NGPAR =NGAVE
      DO 1 M =1,NG
      L =M -1
      I =L *(NGPAR +NSG)
      IGP =I +NSG

C   COMPUTE H FOR EACH SUBJECT IN THE GROUP.
      DO 2 K =1,NSG
      I =I +1

C   EXTRACT THE SUBJECT NUMBER.
      INDEX =IGROPS(I)

C   EXTRACT THE SUBJECT'S I.Q.
      SIQ =SP((INDEX -1) *NSP +1)
      WTEMP =IGROPS(IGP +4)/10000.0
```

```
      WIQD =(WTEMP -SIQ)/DIQ

C   COMPUTE THE SIGNIFICANCE OF THE SUBJECT/GROUP IQ DIFFERENCE.
      DO 3 N =1,5
      IF(WIQD.GT.WIQDI(N)) GO TO 4
    3 CONTINUE
      N =6
    4 WIQ =WIQI(N)

C   EXTRACT THE SUBJECT'S LEARNING RATE AND COURSE ATTITUDE.
C   COMPUTE THE SUBJECT /GROUP LEARNING RATE AND COURSE ATTITUDE
C     DIFFERENCE.
      MPTR =(INDEX -1) *NMEM +2
      WTEMP =IGROPS(IGP +1)/10000.0
      WTEMP2 =IGROPS(IGP +2)/10000.0
      WLRD =(WTEMP -SUMEFF(MPTR))/DLR
      WACD =(WTEMP2 -SUMEFF(MPTR +1)) /DAC

C   COMPUTE THE SIGNIFICANCE OF THE SUBJECT/GROUP LEARNING RATE DIFF.
      DO 5 N =1,5
      IF(WLRD.GT.WLRDI(N)) GO TO 6
    5 CONTINUE
      N=6
    6 WLR =WLRI(N)

C   COMPUTE THE SIGNIFICANCE OF THE SUBJECT/GROUP COURSE ATTITUDE DIFF.
      DO 7 N =1,5
      IF(WACD.GT.WACDI(N)) GO TO 8
    7 CONTINUE
      N =6
    8 WAC =WACI(N)

C   DETERMINE THE SUBJECT'S SEX.
      SSEX =SP((INDEX -1) *NSP +4)

C   WHAT IS THE PERCENT OF THIS SEX IN THE GROUP.
      QMALE =IGROPS(IGP +5)
```

```
      IF(SSEX.LT..01) QMALE =NSG -QMALE
      PCTSS =QMALE/NSG

C  COMPUTE THE SIGNIFICANCE OF SUBJECT/GROUP SEX DIFFERENCE.
      IF(PCTSS.LT..50) GO TO 9
      WSEX =PCTSS *2.0 +.5
      GO TO 10
    9 WSEX =(1.0 -PCTSS) *(-4.0) -.5
   10 IWSEX =WSEX

C  COMPUTE H AND TRANSFORM TO A VALUE BETWEEN 0 AND 1.
      H =(WIQ +WLR +WAC +IWSEX)/16.0
      IF(H.LT.0) H =H *.5
      ADJH =H +.5
    2 SP(INDEX *NSP) =ADJH
    1 CONTINUE
      RETURN
      END
```



```
      SUBROUTINE COMP(INPT,NSGACT)

C  THIS ROUTINE COMPUTES THE POOLED VARIANCE T-TEST STATISTIC FOR ALL
C     PAIRS OF GROUPS SPECIFIED.
      COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
     1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KOEXP,LGNEQ,
     2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
     3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
     4TSCOST

C  IGNEQ IS AN ARRAY OF GROUP NUMBER EQUIVALENCIES.
C  INPT IS AN ARRAY OF GROUPS TO BE COMPARED.
C  LGNEQ IS THE NUMBER OF DEFINED GROUPS.
C  NSGACT IS AN ARRAY CONTAINING THE NUMBER OF ACTIVE GROUP MEMBERS AT
C     THE TIME OF LAST TEST.
```

```
C   PARLIM IS A MATRIX OF LIMITING VALUES FOR THE PARAMETERS. IT IS USED
C     TO INSURE THE PARAMETERS ARE NOT MODIFIED BEYOND BOUNDS.
      DIMENSION INPT(25),NGP(2),NGPT(2),NSGACT(12),T(3),TC(3)

C   EXTRACT FROM THE INPUT CARD THE NUMBERS OF THE GROUPS BEING COMPARED.
      ISW =0
      K =1
      DO 1 I=1,24
      NGP(K) =INPT(I)
      IF (NGP(K).EQ.0) GO TO 1
      NGPT(K) =NGP(K)

C   FIND THE INTERNAL GROUP NUMBER.
      DO 2 J =1,LGNEQ
      IF (IGNEQ(J).EQ.NGP(K)) GO TO 3
    2 CONTINUE
      ISW =1.0
      IF (K.EQ.2) GO TO 4
      K =2
      GO TO 1
    4 WRITE (3,90) NGPT
   90 FORMAT ('0 T-TEST STATISTIC WAS REQUESTED FOR GROUPS',I4,' AND',I4
     1,',ONE OR BOTH OF WHICH ARE UNDEFINED.')
      GO TO 14

C   SAVE THE INTERNAL NUMBER.
    3 NGP(K) =J
      IF (K.EQ.2) GO TO 5
      K =2
      GO TO 1

C   INSURE THAT FIRST MEMBER OF THE PAIR WAS VALID.
    5 IF (ISW.EQ.1) GO TO 4

C   COMPUTE THE TEST STATISTIC.
      NGP1 =NGP(1)
      NGP2 =NGP(2)
```

```
      KSW2 =0
C   COMPUTE DEGREES OF FREEDOM.
      N1 =NSGACT(NGP1)
      N2 =NSGACT(NGP2)
C   INSURE THAT BOTH GROUPS HAVE MEMBERS.
      IF (N1.EQ.0) GO TO 11
      IF (N2.EQ.0) GO TO 11
      NDF =N1 +N2 -2
      IF (NDF.LE.0) GO TO 11
C   INSURE THAT BOTH GROUPS HAVE BEEN PREVIOUSLY TESTED.
      LT1 =NTST(NGP1)
      LT2 =NTST(NGP2)
      IF (LT1.EQ.0) GO TO 12
      IF (LT2.EQ.0) GO TO 12
C   SET POINTERS TO PREVIOUS TEST SCORES.
      IF (LT1.EQ.1) LT1 =4
      IF (LT2.EQ.1) LT2 =4
      LT1 =(LT1 -2) *3
      LT2 =(LT2 -2) *3
C   COMPARE THE MEMORY CELLS.
      DO 7 K =1,3
      LT1 =LT1 +1
      LT2 =LT2 +1
C   EXTRACT SUMS OF SQUARES.
      SS1 =(SSSC(LT1,NGP1) -(ASCORE(LT1,NGP1)/50.0) **2 *N1) *2500.0
      SSC1 =SSCH(LT1,NGP1) -(ACNGE(LT1,NGP1) **2) *N1
      SS2 =(SSSC(LT2,NGP2) -(ASCORE(LT2,NGP2)/50.0) **2 *N2) *2500.0
      SSC2 =SSCH(LT2,NGP2) -(ACNGE(LT2,NGP2) **2) *N2
C   WERE SUMS OF SQUARES STORED?
      IF (SS1.LT.0.0) GO TO 13
```

```
      IF (SS2.LT.0.0) GO TO 13
      SSQD =(SS1 +SS2) /NDF
      SXY =SQRT(SSQD/N1 +SSQD /N2)
      IF(SXY.GT..00001) GO TO 15
      T(K) =99999.9999
      GO TO 16
   15 T(K) =(ASCORE(LT1,NGP1) -ASCORE(LT2,NGP2)) /SXY

C  WERE SUMS OF SQUARES FOR CHANGE FROM PREVIOUS TEST COMPUTED?
   16 IF (SSC1.LT.0.0) GO TO 9
      IF (SSC2.LT.0.0) GO TO 9
      SSQDC =(SSC1 +SSC2) /NDF
      SXYC =SQRT(SSQDC/N1 +SSQDC /N2)
      IF(SXYC.GT..00001) GO TO 17
      TC(K) =99999.9999
      GO TO 7
   17 TC(K) =(ACNGE(LT1,NGP1) -ACNGE(LT2,NGP2)) /SXYC
      GO TO 7
    9 KSW2 =1
    7 CONTINUE
      WRITE (3,91) NGPT,T,NDF
   91 FORMAT ('0 T-TEST STATISTICS FOR GROUPS',I3,' AND ',I2,' -LAST TES
     1T - L RATE =',F10.4,'  COURSE A =',F10.4,'  PEER A =',F10.4,'  DF
     2=',I4)

C  IS GROUP CHANGE TO BE COMPARED?
      IF (KSW2.EQ.1) GO TO 8
      WRITE (3,92) TC
   92 FORMAT (' ',24X,'-CHANGE FROM PREVIOUS TEST - L RATE =',F10.4,'  C
     1OURSE A =',F10.4,'  PEER A =',F10.4)
      GO TO 14
    8 WRITE (3,93)
   93 FORMAT ('  THE CHANGE STATISTICS WERE NOT COMPUTED DUE TO INADEQUA
     1TE INFORMATION. ONLY LATEST TEST SCORES WERE COMPARED.')
      GO TO 14
   11 WRITE (3,94) NGPT
   94 FORMAT ('0 T-TEST STATISTIC WAS REQUESTED FOR GROUPS',I4,' AND',I4
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     1,',ONE OR BOTH OF WHICH HAVE NO MEMBERS.')
      GO TO 14
   12 WRITE (3,95) NGPT
   95 FORMAT ('O T-TEST STATISTIC WAS REQUESTED FOR GROUPS',I4,' AND',I4
     1,',ONE OR BOTH OF WHICH HAVE NOT BEEN TESTED.')
      GO TO 14
   13 WRITE (3,96) NGPT
   96 FORMAT ('O T-TEST STATISTIC WAS REQUESTED FOR GROUPS',I4,' AND',I4
     1,',ONE OR BOTH OF WHICH HAVE NO SUMS OF SQUARES.-PROGRAM ERROR-')
   14 K =1
      ISW =0
    1 CONTINUE
      RETURN
      END


      SUBROUTINE GROUP(INPT,IRAND,IVJFP,IVJFSW,VJFE)

C  THIS ROUTINE ESTABLISHES THE EXPERIMENTAL GROUPS.
      COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
     1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KCEXP,LGNEQ,
     2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
     3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
     4TSCOST

C  IGNEQ IS A VECTOR OF GROUP NUMBER EQUIVALANCIES.THE GROUPS ARE GIVEN
C    NUMBERS IN ORDER OF DEFINITION FOR INTERNAL COMMUNICATIONS.
C  IGROPS IS THE VECTOR OF GROUP MEMBERSHIPS AND GROUP AVERAGES.
C  INPT IS THE GROUP MEMBERSHIP LIST.IT CONTAINS A GROUP NUMBER FOLLOWED
C    BY MEMBER NUMBERS FOR EXPLICIT GROUPING,OR THE NUMBER OF GROUPS AND
C    THE NUMBER OF SUBJECTS PER GROUPS IF RANDOM ASSIGNMENT IS DESIRED.
C  IPS IS A PROGRAM STATUS MARKER.IPS =0 BEFORE A GROUP CARD HAS BEEN
C    ENCOUNTERED, 1 FOLLOWING THE FIRST GRUP CARD,AND 2 WHEN A TEST OR
C    STIM FUNCTION IS INCOUNTERED.
C  ISGN IS A VECTOR OF GROUP MEMBERSHIP BY SUBJECT.
```

```
C   NG IS THE NUMBER OF GROUPS IN THE EXPERIMENT.
C   NGAVE IS THE NUMBER OF GROUP AVERAGES TO BE STORED.
C   NSG IS THE NUMBER OF SUBJECTS PER GROUP.ALL GROUPS MUST BE EQUAL.
C   NSGR IS THE NUMBER OF MEMBERS PER GROUP DURING GROUP CONSTRUCTION.
C   NTST IS THE NUMBER OF TEST GIVEN TO EACH GROUP.
      DIMENSION INPT(1),IRAND(1),IVJFP(10,4),IVJFSW(10),IWK(130),
     1JWK(12),VJFE(10,4)
      DATA COMMA/',')

C   IWK AND JWK ARE WORK ARRAYS.
C   IF THIS IS AN INITIAL ENTRY OR A REDEFINITION OF GROUPS CLEAR RECORDS
      IF (IPS.EQ.1) GO TO 3

C   IS REGROUPING REQUESTED.
      IF (IPS.GE.3) GO TO 14
      LGNEQ =0
      DO 1 I =1,12
    1 NSGR(I) =0
      DO 2 I =1,NOSS
    2 ISGN(I) =0

C   DETERMINE TYPE OF GROUP DEFINING TO BE USED.
    3 IGP =INPT(1)
      IF(IGP.EQ.0) GO TO 4

C   HAS THIS GROUP BEEN PARTIALLY DEFINED?
      LGNEQ =LGNEQ +1
      IGNEQ(LGNEQ) =IGP
      LL =LGNEQ
      TSCOST =TSCOST +COST(1)
      DO 5 I =1,LL
      IF (IGNEQ(I).NE.IGP) GO TO 5
      IF (I.EQ.LL) GO TO 32
      LGNEQ =LGNEQ -1
      TSCOST =TSCOST -COST(1)
      GO TO 31
   32 WRITE (3,97) IGP
```

```
   97 FORMAT ('0 GROUP ',I4,' WAS EXPLICITLY DEFINED.')
   31 IF (I.GT.NG) NG =I
      IF (I.EQ.13) GO TO 6
      IGP =I
      NTST(I) =0
      NTSTT(I) =0
      GO TO 7
    5 CONTINUE
C  EXTRACT CARDINAL NUMBER OF NEXT MEMBER OF THIS GROUP.
    7 INDX =NSGR(IGP)
C  COMPUTE INDEX FOR STORING ON MEMBERSHIP LIST.
      MAX =(IGP-1) *(NSG +NGAVE)
      IXGP =MAX +INDX
      MAX =MAX +NSG
C  PUT NEW MEMBERS ON LIST.
      DO 8 I=2,24
      MEMB =INPT(I)
C  ASSURE MEMBER IS LEGAL.
      IF(MEMB.EQ.0) GO TO 8
      IF(MEMB.GT.NOSS) GO TO 9
      IF(ISGN(MEMB).NE.0) GO TO 10
C  ADD MEMBER TO LIST.
      IXGP =IXGP +1
      IF(IXGP.GT.MAX) GO TO 11
      IGROPS(IXGP) =MEMB
      INDX =INDX +1
C  STORE GROUP AFFILIATION.
      ISGN(MEMB) =IGP
      GO TO 8
    9 WRITE (3,90) MEMB,IGP,NOSS
   90 FORMAT ('0 SUBJECT ',I5,' WAS ASSIGNED TO GROUP ',I4,'. ONLY',I4,
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     1 ' SUBJECTS ARE AVAILABLE. THIS MEMBER WAS IGNORED.')
      GO TO 8
   10 IF(ISGN(MEMB).EQ.IGP) GO TO 8
      WRITE (3,91) MEMB,ISGN(MEMB),IGP
   91 FORMAT ('0 SUBJECT ',I3,' WAS ASSIGNED TO GROUPS ',I3,' AND ',I3,
     1'.GROUP ASSIGNMENTS MUST BE UNIQUE. THIS REQUEST WAS IGNORED.')
      GO TO 8
   11 WRITE (3,93) NSG,IGNEQ(IGP)
   93 FORMAT('0 MORE THAN',I4,' SUBJECTS WERE ASSIGNED TO GROUP',I4,' TH
     1E EXCESS WILL BE IGNORED.')
    8 CONTINUE
      NSGR(IGP)=INDX
      IF (KOEXP.EQ.0) CALL VJF(IGP,1,IVJFSW,IVJFP,VJFE)
      RETURN
    6 WRITE (3,92) IGP
   92 FORMAT ('0 MORE THAN 12 GROUPS HAVE BEEN REQUESTED. THE REQUEST FO
     1R GROUP',I4,' WAS IGNORED.')
      RETURN

C  IS THIS A SHUFFLE OF CLASSES.
   14 NUMSUB =0
      IF (IPS.EQ.3) GO TO 15

C  PLACE ALL UNASSIGNED SUBJECTS IN THE GRAB BAG.
      DO 16 I =1,NCSS
      IF (ISGN(I).NE.0) GO TO 16
      NUMSUB =NUMSUB +1
      IWK(NUMSUB) =I
   16 CONTINUE

C  DETERMINE THE NUMBER OF GROUPS INVOLVED.
   15 NGPS =0
      DO 17 I =2,24

C  SAVE THE GROUP NUMBER.
      NGRP =INPT(I)
      IF (NGRP.EQ.0) GO TO 17
```

```
C   IS THIS A KNOWN GROUP?
       DO 18 L =1,12
       IF (NGRP.NE.IGNEQ(L)) GO TO 18
       TSCOST =TSCOST +COST(1)
       NGPS =NGPS +1

C   PUT GROUP NUMBER ON TEMPORARY LIST.
       JWK(NGPS) =L
       IGP =L
       GO TO 19
    18 CONTINUE

C   THE GROUP WAS NOT PREVIOUSLY DEFINED.
       IF (LGNEQ.GE.12) GO TO 30
       IF ((NGPS +1) *NSG.GT.NOSS) GO TO 30
       TSCOST =TSCOST +COST(1)
       LGNEQ =LGNEQ +1
       IF (LGNEQ.GT.NG) NG =LGNEQ
       IGNEQ(LGNEQ) =NGRP
       NGPS =NGPS +1
       JWK(NGPS) =LGNEQ
       GO TO 17
    30 WRITE (3,94) NGRP
    94 FORMAT ('0 A REQUEST WAS MADE TO REGROUP GROUP NUMBER',I5,' WHICH
      1WAS NOT PREVIOUSLY DEFINED. THE GROUP OR SUBJECT LIMITS DO NOT PER
      2MIT.')
       GO TO 17

C   DUE TO REGROUPING THE GROUP SCORES MUST BE PRINTED.
    19 IF (KOEXP.EQ.0) CALL OUTPT(IGP)

C   ADD MEMBERS OF THIS GROUP TO THE GRAB BAG.
C   FIND LIST OF GROUP MEMBERS.
       INDEX =(IGP -1) *(NSG +NGAVE) +1
       MAX =INDEX +NSG -1
       DO 20 L =INDEX,MAX
```

```
      NUMSUB =NUMSUB +1
      IWK(NUMSUB) =IGROPS(L)
C   FREE SUBJECT FROM GROUP AFFILIATION.
      ISGN(IGROPS(L)) =0
   20 CONTINUE
   17 CONTINUE
C   CLEAR UNUSED SPACE IN GRAB BAG.
      IF (NUMSUB.EQ.NOSS) GO TO 21
      IN =NUMSUB +1
      DO 22 I =IN,NOSS
   22 IWK(I) =0
C   SHUFFLE THE GRAB BAG.
   21 IY =IY *65539
      IF (IY.LT.0) IY =IY +2147483647 +1
      YFL =IY
      YFL =YFL *.4656613E-9
      NUMT =YFL *NOSS +1
      DO 23 I=1,NOSS
      NUMT =NUMT +1
      IF(NUMT.GT.NOSS) NUMT =1
      NTEMP =IRAND(NUMT)
      ITEMP =IWK(NTEMP)
      IWK(NTEMP) =IWK(I)
   23 IWK(I) =ITEMP
C   REFORM GROUPS.
      K =0
      DO 24 I =1,NGPS
C   SELECT A GROUP NUMBER.
      IGP =JWK(I)
      NTST(IGP) =0
      NTSTT(IGP) =0
      INDEX =(IGP -1) *(NSG +NGAVE)
```

```
      DO 25 L =1,NSG
   26 K =K +1
C  DID THE GRAB PRODUCE AN ELEMENT?
      NSUB =IWK(K)
      IF (NSUB.EQ.0) GO TO 26
      INDEX =INDEX +1
C  PUT SUBJECT ON GROUP LIST.
      IGROPS(INDEX) =NSUB
C  AFFIX GROUP MEMBERSHIP STATUS TO SUBJECT.
      ISGN(NSUB) =IGP
   25 CONTINUE
      IF (KOEXP.EQ.0) CALL VJF(IGP,1,IVJFSW,IVJFP,VJFE)
   24 CONTINUE
      LPRT =NGPS -1
      IF (LPRT.NE.0) GO TO 33
      WRITE (3,95) IGNEQ(1)
      RETURN
   33 WRITE (3,95) (IGNEQ(JWK(I)),COMMA,I=1,LPRT),IGNEQ(NGPS)
   95 FORMAT ('0 THE FOLLOWING GROUPS WERE REDEFINED : ',12(I3,A1))
      RETURN
C  RANDOMLY ASSIGN SUBJECTS TO GROUPS.
    4 K =0
      TSCOST =TSCOST +COST(1) *NG
      I =0
      DO 12 J =1,NG
      NTST(J) =0
      NTSTT(J) =0
      IGNEQ(J) =J
      DO 13 L =1,NSG
      K =K +1
      I =I +1
      IGROPS(I) =K
   13 ISGN(K) =J
```

```
      IF (KOEXP.EQ.0) CALL VJF(J,1,IVJFSW,IVJFP,VJFE)
   12 I =I +NGAVE
      LGNEQ =NG
      LPRT =NG -1
      IF (LPRT.NE.0) GO TO 34
      WRITE (3,96) IGNEQ(1)
      RETURN
   34 WRITE (3,96) (IGNEQ(J),COMMA,J=1,LPRT),IGNEQ(LGNEQ)
   96 FORMAT ('0 THE FOLLOWING GROUPS WERE IMPLICITLY DEFINED : ',
     1 12(I3,A1))
      RETURN
      END


      SUBROUTINE STIM(C,INPT,IVJFP,IVJFSW,LV,NDIMEN,VJFE)
C  THIS ROUTINE ADMINISTERS THE STIMULUS TO THE SUBJECTS AND CHANGES THE
C     SUBJECT'S MEMORY BY THE APPROPRIATE AMOUNT.
      COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
     1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KOEXP,LGNEQ,
     2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
     3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
     4TSCOST
      DIMENSION C(3),IGSTIM(12),INPT(25),IVJFP(10,4),IVJFSW(10),
     1LV(7),LS(7),VJFE(10,4)

C  INPT IS AN ARRAY OF PARAMETERS AND GROUPS TO BE STIMULATED.
C     POSITION -1 AND 2 CONTAIN THE STIMULUS CHARACTERISTICS -LEFT ADJ.
C              3 THE NUMBER OF REPLICATIONS OF THIS STIMULUS.
C              4 THRU 15 THE NUMBERS OF THE GROUPS TO BE STIMULATED.
C  ICARD IS THE INPUT CARD NUMBER.
C  IGNEQ IS AN ARRAY OF GROUP NUMBER EQUIVALENCIES.
C  IVJFF CONTAINS THE NUMBER OF THE PARAMETERS AFFECTED BY EACH VJF.
C  IVJFSW IS A VECTOR OF SWITCHES FOR THE VJFS (ON =1,OFF =0).
C  KOEXP IS A SWITCH TO TERMINATE THE EXPERIMENT FOLLOWING A SYNTAX
```

```
C     ERROR CHECK OF THE DATA CARDS.
C   LGNEQ IS THE NUMBER OF ENTRIES IN IGNEQ.
C   NDIMEN THE NUMBER OF STIMULUS CHARACTERISTICS PERCEIVED.
C   NSG IS THE NUMBER OF SUBJECTS PER GROUP.
C   SUMEFF IS THE MEMORY ARRAY FOR ALL SUBJECTS.
C   VJFE CONTAINS THE PERCENT A PARAMETER IS TO CHANGE AS A RESULT OF
C     AN ENVOKED VJF.
      DATA COMMA/',''/
      DO 9 I =1,6
    9 LS(I) =0

C   DETERMINE THE STIMULUS.
      L =1
      IF (NDIMEN.GT.3) L =2
      I =0

C   EXTRACT AND SEGMENT THE STIMULUS.
      DO 1 J =1,L
      K =INPT(J)
      DO 4 IW =1,3
      NSF =10 **(3 -IW)
      N =K/NSF
      IF (N.NE.0) GO TO 2
    3 WRITE (3,90) ICARD,(INPT(M),M=1,2)
   90 FORMAT ('0 ON INPUT CARD',I3,' THE STIMULUS WAS NOT SPECIFIED CORR
     1ECTLY IN COLUMNS 5-10. THE FIELD CONTAINS ',2I3)
      KOEXP =1
      GO TO 5
    2 K =K -N *NSF
      I =I +1
      LS(I) =N
      IF(I.EQ.NDIMEN) GO TO 5
    4 CONTINUE
    1 CONTINUE

C   STORE THE REPLICATION FACTOR.
    5 NR =INPT(3)
```

```
      IF(NR.EQ.0) NR =1
C   STORE GROUPS TO RECEIVE THIS TREATMENT.
      LGSTIM =0
      DO 6 J=4,24
      K =INPT(J)
      IF (K.EQ.0) GO TO 6
C   HAS THIS GROUP BEEN DEFINED?
      I =1
    7 IF (K.EQ.IGNEQ(I)) GO TO 8
      I =I +1
      IF (I.LE.LGNEQ) GO TO 7
      WRITE (3,91) ICARD,LS,K
   91 FORMAT ('0 INPUT CARD',I3,' REQUESTED THAT STIMULUS',6I1,' BE GIVE
     1N TO GROUP',I4,' WHICH IS UNDEFINED.')
      KOEXP =1
      GO TO 6
C   A VALID GROUP HAS BEEN SPECIFIED.
    8 LGSTIM =LGSTIM +1
      IGSTIM(LGSTIM) =I
    6 CONTINUE
C   IF NO GROUPS WERE SPECIFIED,TREAT ALL GROUPS.
      IF (KOEXP.EQ.1) RETURN
      IF(LGSTIM.NE.0) GO TO 10
      DO 11  I =1,LGNEQ
   11 IGSTIM(I) =I
      LGSTIM =LGNEQ
C   IF EXPERIMENT IS PROPERLY DEFINED APPLY TREATMENT.
   10 IF (KOEXP.EQ.1) GO TO 12
C   TREAT ALL GROUPS.
      DO 13 I =1,LGSTIM
      NOGP =IGSTIM(I)
```

```
C   SET POINTERS TO FIRST AND LAST MEMBER OF THE GROUP.
       INIT =(NOGP -1) *(NSG +NGAVE) +1
       LAST =INIT +NSG-1

C   REPLICATE THE TREATMENT.
       DO 14 J =1,NR

C   SHOULD VJF'S BE INVOKED?
       KVJF =IGSW(NOGP,4)
       IF(KVJF.NE.0) CALL VJF(NOGP,4,IVJFSW,IVJFP,VJFE)

C   TREAT EACH STUDENT IN THE GROUP.
       DO 15 K =INIT ,LAST
       TSCOST =TSCOST +COST(4)
       IND =IGROPS(K)

C   ESTABLISH POINTER TO SUBJECT'S MEMORY.
       MPTR=(IND -1) *NMEM +1

C   DETERMINE THE EFFECT OF THE TREATMENT.
       CALL EFFECT(C,IND,LS,LV,MPTR)
       R =SUMEFF(MPTR)
       RPO =R +1.
       SUMEFF(MPTR) =RPO
       DO 16 L=1,NDIMEN
       M =MPTR +L
    16 SUMEFF(M) =(SUMEFF(M) *R +C(L))/RPO
    15 CONTINUE

C   SHOULD POST-STIMULUS VJF'S BE INVOKED?
       KVJF =IGSW(NOGP,5)
       IF(KVJF.NE.0) CALL VJF(NOGP,5,IVJFSW,IVJFP,VJFE)
    14 CONTINUE
    13 CONTINUE
       LPRT =LGSTIM -1
       IF (LPRT.NE.0) GO TO 17
```

```
      WRITE (3,92) NR,(LS(I),I=1,6),IGNEQ(IGSTIM(1))
      GO TO 12
   17 WRITE (3,92) NR,(LS(I),I=1,6),(IGNEQ(IGSTIM(I)),COMMA,I=1,LPRT),
     1 IGNEQ(IGSTIM(LGSTIM))
   92 FORMAT ('0 THE FOLLOWING GROUPS RECEIVED',I4,' REPLICATIONS OF TRE
     1ATMENT ',6I1,'  :',12(I3,A1))
   12 CONTINUE
      RETURN
      END



      SUBROUTINE TEST(INPT,IVJFP,IVJFSW,NSGACT,VJFE)
C  THIS ROUTINE MEASURES STUDENT CHARACTERISTICS.
      COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
     1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KOEXP,LGNEQ,
     2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
     3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
     4TSCOST
C  ACNGE IS A MATRIX OF PRE -POST DEVIATIONS AVERAGED BY GROUP.
C  ASCORE IS A MATRIX OF AVERAGE TEST SCORES BY GROUP.
C  ICARD IS THE INPUT CARD NUMBER.
C  IGNEQ IS A VECTOR OF GROUP NUMBER EQUIVALENCIES. THE GROUPS ARE
C    NUMBERED IN ORDER OF DEFINITION FOR INTERNAL COMMUNICATION.
C  IGROPS IS THE VECTOR OF GROUP MEMBERSHIP AND GROUP AVERAGES.
C  INPT -POSITION ONE REQUESTS AVERAGE SCORES ONLY (VALUE =1),OR AVERAGE
C    SCORES AND AVERAGE DEVIATIONS (VALUE =2). THE FOLLOWING POSITIONS
C    SPECIFY GROUPS TO BE TESTED.
C  LGNEQ IS THE NUMBER OF DEFINED GROUPS.
C  LTS IS A VECTOR OF THE NUMBER (MOD 3) OF PREVIOUS TESTS BY SUBJECT.
C  NG IS THE NUMBER OF GROUPS IN THE EXPERIMENT.
C  NGAVE IS THE NUMBER OF GROUP AVERAGES TO BE STORED.
C  NSG IS THE NUMBER OF SUBJECTS PER GROUP.
C  NTST IS A VECTOR OF TEST COUNTS PER GROUP.
```

```
C   SSCH IS A MATRIX OF SUMMED SQUARED CHANGE DEVIATICNS BY GROUP.
C   SSSC IS A MATRIX OF SUMMED SQUARED SCORE DEVIATIONS BY GROUP.
C   TSCORE IS A MATRIX OF TEST SCORES TO BE PRINTED.
       DIMENSION CHSTAT(3)
       DIMENSION DEVCH(3,130),DEVSC(3,130),IERRV(130),IGTBT(12),
      1INPT(1),IVJFP(10,4),IVJFSW(10),NSGACT(12),SD(3),SS(3),SUMCH(3),
      2SUMSC(3),VJFE(10,4)
       DATA COMMA/','/

C   DETERMINE THE TYPE OF GROUP AVERAGES TO ACCUMULATE.
       ITYPE =INPT(1)
       INPT(25) =0
       IF (ITYPE.EQ.0) GO TO 1
       IF (ITYPE.LT.3) GO TO 2
       WRITE (3,90) ICARD,ITYPE
    90 FORMAT ('0 INPUT CARD',I3,'CONTAINS THE NUMBER',I4,' IN COLS 5-7.
      1IT IS ASSUMED THAT THIS IS A GROUP NUMBER. ONLY AVERAGE ON SCORES
      2WILL BE COMPUTED.')
       INPT(25) =ITYPE
     1 ITYPE =1

C   EXTRACT THE NUMBERS OF THE GROUPS TO BE TESTED.
     2 NTG =0
       DO 3 I =2,25
       IGP =INPT(I)
       IF (IGP.EQ.0) GO TO 3
       DO 4 J =1,LGNEQ
       IF (IGP.NE.IGNEQ(J)) GO TO 4
       NTG =NTG +1

C   PUT GROUP NUMBER ON TEST LIST.
       IGTBT(NTG) =J
       GO TO 3
     4 CONTINUE
       WRITE (3,91) ICARD,IGP
    91 FORMAT ('0 INPUT CARD',I3,' REQUESTED GROUP',I4,' TO BE TESTED. TH
      1IS GROUP IS UNDEFINED. REQUESTED IGNORED.')
```

```
    3 CONTINUE
      IF (KOEXP.EQ.1) RETURN

C  IF NO GROUPS WERE SPECIFIED,TEST ALL GROUPS.
      IF (NTG.NE.0) GO TO 5
      NTG =NG
      DO 6 I =1,NG
    6 IGTBT(I) =I

C  ADMINISTER THE TEST.
C  TEST ALL GROUPS REQUESTED.
    5 DO 7 I =1,NTG
      IERR =0

C  CLEAR TOTAL ACCUMULATORS.
      DO 8 K =1,3
      SS(K) =0.0
      SD(K) =0.0
      SUMCH(K) =0.0
    8 SUMSC(K) =0.0
      NOGP =IGTBT(I)

C  SHOULD VALIDITY JEOPARDIZING FACTORS BE INVOKED?
      KVJF =IGSW(NOGP,2)
      IF(KVJF.NE.0) CALL VJF(NOGP,2,IVJFSW,IVJFP,VJFE)

C  DETERMINE NUMBER OF THIS TEST.
      NT =NTST(NOGP)
      NTT =NT
      IF(NT.EQ.0) NT =1

C  INCREMENT THE NUMBER OF TESTS FOR THIS GROUP.
      NTST(NOGP) =NT +1
      NTSTT(NOGP) =NTSTT(NOGP) +1

C  TEST AND COMPARE AVERAGE SCORES.
      ITYPW =ITYPE
```

```
      INSG =0
      INDX =(NOGP -1) *(NSG +NGAVE)
      DO  9 K =1,NSG
      TSCOST =TSCOST +COST(3)
      INSG =INSG +1
      INDX =INDX +1

C   DETERMINE SUBJECTS TO BE TESTED.
      IND =IGROPS(INDX)

C   WHERE WAS SUBJECTS PREVIOUS TEST SCORE PLACED?
      LSCORE =LTS(IND)
      LPTR =(LSCORE -1) *3
      IPTR =(NT -1) *3

C   IF SO IS THIS THE FIRST TEST AFTER REGROUPING?
      IF(NTT.NE.0) GO TO 10

C   ARE PRE-POSTTEST DIFFERENCES TO BE COMPUTED?
      IF(ITYPE.EQ.1) GO TO 10

C   IF SO INSURE THAT EACH SUBJECT'S PREVIOUS TEST SCORE IS IN THE LAST
C     POSITION OF THE OUTPUT MATRIX.

C   WAS SUBJECT PREVIOUSLY TESTED?
      IF (LSCORE.NE.0) GO TO 11
      IF (IERR.NE.0) GO TO 12
      WRITE (3,92) IGNEQ(NOGP)
   92 FORMAT ('0 PRETEST-POSTTEST DIFFERENCES WERE REQUESTED FOR GROUP',
     1I4,'. SINCE NO PRETEST WAS GIVEN,POSTTEST REQUEST WAS IGNORED ')

C   SET DIFFERENCE COMPUTATION SWITCH TO NO FOR THIS GROUP
      ITYPW =1
   12 IERR =IERR +1

C   ADD INDIVIDUAL TO THE ERROR LIST.
      IERRV(IERR) =IND
```

```
      GO TO 10
C  WAS LAST SCORE STORED IN LAST POSITION OF OUTPUT VECTOR?
   11 IF (LSCORE.GT.2) GO TO 10
C  IF NOT -PUT IT THERE.
      DO 13 L =1,3
   13 TSCORE(6+L,IND) =TSCORE(LPTR +L,IND)
      LPTR =6
C  TRANSFER THE SUBJECT'S SCORE TO THE OUTPUT MATRIX.
   10 MEM =(IND -1) *NMEM +1
      IF (LSCORE.NE.4) GO TO 14
      INSG =INSG -1
C  A LSCORE OF 4 INDICATES THE SUBJECT HAS DROPPED THE GROUP.
      GO TO 9
   14 LTS(IND) =NT
      DO 15 L =1,3
      SCORE =SUMEFF(MEM +L)
C  COMPUTE GROUP TOTALS.
C   SAVE SUBJECT'S SCORES FOR CONVENIENCE.
      DEVSC(L,INSG) =SCORE
      SUMSC(L) =SUMSC(L) +SCORE
      TSCORE(IPTR +L,IND) =SCORE
C  SAVE SUM OF SQUARED (SCORES DIVIDED BY 50).
      SS(L) =SS(L) +(SCORE/50.0) **2
C  ARE PRETEST -POSTTEST DIFFERENCES TO BE COMPUTED?
      IF (ITYPW.EQ.1) GO TO 15
      CHANGE =SCORE -TSCORE(LPTR +L,IND)
      SUMCH(L) =SUMCH(L) +CHANGE
C  SAVE SUM OF SQUARED CHANGES.
      SD(L) =SD(L) +CHANGE *CHANGE
```

```
C    SAVE SUBJECT'S SCORE CHANGE FOR CONVENIENCE.
      CHSTAT(L) =CHANGE
      DEVCH(L,INSG) =CHANGE
   15 CONTINUE

C   THE FOLLOWING 10 CARDS CAN BE USED TO PUNCH OUTPUT CARDS CONTAINING
C     DIFFERENCES AND PARAMETERS FOR EACH SUBJECT GIVEN A POSTTEST.
C     IF VJF SWITCHES ARE ON,THE PARAMETERS MAY HAVE BEEN MODIFIED.
C      IF(ITYPW.EQ.1) GO TO 9
C      LC =(IND -1) *16
C      LE =LC +1
C      LF =LC +3
C      WRITE (2,1998) I,IND,CHSTAT,(SP(LD),LD =LE,LF),SP(LC+5)
C1998 FORMAT (I3,I3,'1'   ,3X,7F10.6)
C      LE =LC +6
C      LF =LC +11
C      WRITE (2,1999) I,IND,(SP(LD),LD =LE,LF)
C1999 FORMAT (I3,I3,'2'   ,3X,7F10.6)
    9 CONTINUE

C   WRITE OUT ERROR VECTOR.
      IF (IERR.EQ.0) GO TO 16
      IF (IERR.NE.NSG) GO TO 32
      WRITE (3,96)
   96 FORMAT ('0    FOR ALL SUBJECTS.')
      GO TO 16
   32 WRITE (3,93) (IERRV(L),L=1,IERR)
   93 FORMAT ('0',26(I4,','))

C   COMPUTE AVERAGES FOR THE GROUP.
   16 IF (INSG.GT.0) GO TO 17
      WRITE (3,94) IGNEQ(NOGP)
   94 FORMAT ('0 GROUP NUMBER',I4,' HAS NC MEMBERS HENCE NO AVERAGES.')
      GO TO 7
   17 ITEMP =(NT -1) *3
      NSGACT(NOGP) =INSG
```

```
      XNSG =INSG
      IF (INSG.EQ.0) GO TO 24
      DO 18 L =1,3
      JTEMP =ITEMP +L
C   COMPUTE AVERAGE FOR RAW TEST SCORE.
      SUMSC(L) =SUMSC(L) /XNSG
      ASCORE (JTEMP,NOGP) =SUMSC(L)
      IF (ITYPW.EQ.1) GO TO 19
C   COMPUTE AVERAGE DEVIATIONS.
      SUMCH(L) =SUMCH(L) /XNSG
      ACNGE(JTEMP,NOGP) =SUMCH(L)
      GO TO 18
   19 ACNGE(JTEMP,NOGP) = -1.0
   18 CONTINUE
C   STORE THE SUMS OF SQUARES IN THE OUTPUT MATRIX.
      DO 23 L =1,3
      JTEMP =ITEMP +L
      SSSC(JTEMP,NOGP) =SS(L)
      IF (ITYPW.EQ.1) SD(L) =-1
   23 SSCH(JTEMP,NOGP) =SD(L)
C   SHOULD VJF'S BE INVOKED?
      KVJF =IGSW(NOGP,3)
      IF(KVJF.NE.0) CALL VJF(NOGP,3,IVJFSW,IVJFP,VJFE)
      GO TO 26
   24 WRITE (3,97) NOGP
   97 FORMAT ('0 ALL MEMBERS OF GROUP',I4,' HAVE DROPPED OUT OF THE EXPE
     1RIMENT.')
      DO 25 L=1,3
      JTEMP =ITEMP +L
      ASCORE(JTEMP,NOGP) =-1.0
      ACNGE(JTEMP,NOGP) =-1.0
      SSSC(JTEMP,NOGP) =-1.0
   25 SSCH(JTEMP,NOGP) =-1.0
```

```
C   IF THIS IS THE THIRD TEST,WRITE SCORES.
   26 IF (NT.NE.3) GO TO 7
      CALL OUTPT(NOGP)
      NTST(NOGP) =1
    7 CONTINUE

C   STATE PROGRESS OF THE EXPERIMENT.
      LPRT =NTG -1
      IF (LPRT.NE.0) GO TO 27
      WRITE (3,95) IGNEQ(IGTBT(1))
      RETURN
   27 WRITE (3,95) (IGNEQ(IGTBT(I)),COMMA,I=1,LPRT),IGNEQ(IGTBT(NTG))
   95 FORMAT ('0 THE FOLLOWING GROUPS WERE TESTED : ',12(I3,A1))
      RETURN
      END



      SUBROUTINE OUTPT(NOGP)

C   THIS ROUTINE PRINTS TNE TEST SCORES AND AVERAGES.
      COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
     1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KOEXP,LGNEQ,
     2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
     3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
     4TSCOST

C   ACNGE IS AN ARRAY OF PRE -POST DIFFERENCES AVERAGED BY GROUP.
C   ASCORE IS AN ARRAY OF AVERAGE TEST SCORES BY GROUP.
C   ICT IS THE NUMBER OF ACTIVE MEMBERS OF A GROUP.
C   IGNEQ IS AN ARRAY OF GROUP NUMBER EQUIVALENCIES.
C   IGROPS IS THE ARRAY OF GROUP MEMBERSHIP AND GROUP AVERAGES.
C   LGNEQ IS THE NUMBER OF GROUPS CURRENTLY DEFINED.
C   LTS IS AN ARRAY OF THE NUMBER (MOD 3) CF PREVIOUS TESTS BY SUBJECT.
C   NGAVE IS THE NUMBER OF GROUP AVERAGES STORED IN THE IGROPS ARRAY
```

```
C      BETWEEN THE MEMBERSHIP LISTS.
C   NOGP IS THE ID NUMBER OF THE GROUP TO BE PRINTED. IF NOGP =-5 PRINT
C      ALL GROUPS.
C   NPRT IS THE NUMBER OF GROUPS TO BE PRINTED.
C   NSG IS THE NUMBER OF SUBJECTS PER GROUP.
C   NTST IS AN ARRAY OF UNPRINTED TEST COUNTS PER GROUP.
C   NTSTT IS AN ARRAY OF TOTAL TEST CCUNTS PER GROUP.
C   SSCH IS AN ARRAY OF SUMS OF SQUARES OF INDIVIDUAL CHANGES WITHIN THE
C      GROUP.
C   SSSC IS AN ARRAY OF SUMS OF SQUARES OF INDIVIDUAL CIFFERENCES WITHIN
C      THE GROUP.
C   TSCORE IS THE ARRAY OF TEST SCORES TO BE PRINTED.
      DIMENSION IWK(3),ICT(3)
      DATA TEST/'TEST'/
      DATA PARN/'('/
      NPRT =1
      ICTR =NOGP

C   ARE THE SCORES OF ALL GROUPS TO BE PRINTED.
      IF (NOGP.NE.-5) GO TO 1
      NPRT =LGNEQ

C   ESTABLISH COUNTERS TO PRINT ALL GROUPS.
      ICTR =0
    2 ICTR =ICTR +1
      NOGP =IGNEQ(ICTR)

C   WRITE HEADERS.
C   DETERMINE THE NUMBER OF TESTS TO BE PRINTED FOR THIS GROUP.
    1 N =NTST(ICTR) -1
      DO 11 I =1,3
   11 ICT(I) =0
      IF(N.LT.1) GO TO 13
      WRITE (3,90) NOGP
   90 FORMAT ('0',53X,'TEST SCCRES FOR GROUP',I4)

C   DETERMINE THE NUMBER OF THE TEST.
```

```
      NTGP =NTSTT(ICTR)
      K =NTGP -N +1
C  PREPARE TO OUTPUT THE NUMBER OF THE TEST.
      DO 3 I =1,N
      IWK(I) =K
    3 K =K +1
      WRITE (3,91) (TEST,IWK(I),I=1,N)
   91 FORMAT (' ',3(25X,A4,I3,6X))
      DO 4 I =1,N
    4 IWK(I) =I
      WRITE (3,92) (IWK(I),I =1,N)
   92 FORMAT ('  SUBJ NO.',3(I2,'LEARN RATE COURSE ATT.  GROUP ATT.',
     1 3X))
C  PRINT SCORES FOR EACH MEMBER OF THE GROUP.
      INDX =(ICTR -1) *(NSG +NGAVE)
      DO 5 I =1,NSG
      LSTN =N
      INDX =INDX +1
      IND =IGROPS(INDX)
C  WAS THIS SUBJECT A DROP OUT?
      LSCORE =LTS(IND)
      IF(LSCORE.NE.4) GO TO 6
C  IF SO DETERMINE WHEN.
      K =-2
      DO 7 J =1,3
      K =K +3
      IF (TSCORE(K,IND).NE.-1.0) GO TO 7
      LSTN =J -1
      IF (LSTN.NE.0) GO TO 12
      WRITE (3,100) IND
  100 FORMAT ('0',I5,' DROP -OUT')
      GO TO 5
   12 DO 8 L =1,LSTN
```

```
    8 ICT(L) =ICT(L) +1
      GO TO 9
    7 CONTINUE
    6 DO 10 J=1,N
   10 ICT(J) =ICT(J) +1
      LSTN =LSTN *3
C  ARE INDIVIDUAL SCORES TO BE PRINTED?
    9 IF(IGPIS.NE.1) GO TO 5
      WRITE (3,93) IND,(TSCORE(J,IND),TSCORE(J+1,IND),TSCORE(J+2,IND),
     1 J =1,LSTN,3)
   93 FORMAT ('0',I6,3(3X,3F12.6))
    5 CONTINUE
C  OUTPUT AVERAGES.
      WRITE (3,101)
  101 FORMAT ('0',58X,'AVERAGE SCORES')
      WRITE (3,94) (PARN,ICT(J),J=1,N)
   94 FORMAT ('0',3(22X,A1,I3,' SUBJECTS)',2X))
      N =N *3
      WRITE (3,95) (ASCORE(J,ICTR),ASCORE(J+1,ICTR),ASCORE(J+2,ICTR),J=1
     1,N,3)
   95 FORMAT ('0',6X,3(3X,3F12.6))
      WRITE (3,96)
   96 FORMAT ('0',50X,'SUMS OF SQUARES OF (SCORES/50)')
      WRITE (3,97) (SSSC(J,ICTR),SSSC(J+1,ICTR),SSSC(J+2,ICTR),J =1,N,3)
   97 FORMAT ('0',6X,3(3X,3F12.4))
      WRITE (3,98)
   98 FORMAT ('0',48X,'AVE CHANGE FROM PREVIOUS TEST SCORE')
      WRITE (3,95) (ACNGE(J,ICTR),ACNGE(J+1,ICTR),ACNGE(J+2,ICTR),J=1,N,
     1 3)
      WRITE (3,99)
   99 FORMAT ('0',50X,'SUMS OF SQUARES OF DEVIATIONS')
      WRITE (3,97) (SSCH(J,ICTR),SSCH(J+1,ICTR),SSCH(J+2,ICTR),J=1,N,3)
C  DETERMINE IF ALL SPECIFIED GROUPS HAVE BEEN PROCESSED.
      NTST(NOGP) =1
```

```
 13 IF(ICTR.LT.NPRT) GO TO 2
    RETURN
    END



    SUBROUTINE GRPAVE

C   THIS ROUTINE COMPUTES GROUP AVERAGES FOR EACH GROUP IN THE EXPERIMENT
    COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
   1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KOEXP,LGNEQ,
   2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
   3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
   4TSCOST

C   IGROPS IS A MATRIX OF GROUP MEMBERSHIPS AND AVERAGES.
C   NG IS THE NUMBER OF GROUPS IN THE EXPERIMENT.
C   NGAVE IS THE NUMBER OF GROUP AVERAGES.
C   NMEM IS THE NUMBER OF MAIN MEMORY CELLS FOR EACH SUBJECT.
C   NSG IS THE NUMBER OF SUBJECTS IN EACH EXPERIMENTAL GROUP.
C   SP IS THE MATRIX OF SUBJECT PARAMETERS AND TEMPORARY STORAGE.
C   SUMEFF IS THE MAIN MEMORY FOR ALL SUBJECTS (SUMMARY OF EFFECTS).
    LAST =-NGAVE

C   COMPUTE AVERAGES FOR ALL GROUPS.
    DO 1 I=1,NG

C   INNITIALIZE ACCUMULATORS.
    ALR =0.0
    AAC =0.0
    AAG =0.0
    ASIQ =0.0
    ASEX =0.0
    LAST =LAST +NGAVE +NSG
    INIT =LAST -NSG +1
```

```
C  EXTRACT AND ACCUMULATE VALUES FOR EACH MEMBER CF THE GRCUP.
      DO 2 J=INIT,LAST

C  FIND THE MEMBERS OF THE GROUP.
      IND =IGROPS(J)
      INDSP =(IND -1) *NSP +1

C  ACCUMULATE IQ.
      ASIQ =ASIQ +SP(INDSP)

C  CCUNT THE NUMBER OF MALE MEMBERS.
      IF(SP(INDSP +3).NE.0.0) ASEX =ASEX +1.0
      MEM =(IND -1) *NMEM

C  ACCUMULATE LEARNING RATE.
      ALR =ALR +SUMEFF(MEM +2)

C  ACCUMULATE COURSE ATTITUDE.
      AAC =AAC +SUMEFF(MEM +3)

C  ACCUMULATE GROUP ATTITUDE.
      AAG =AAG +SUMEFF(MEM +4)
    2 CONTINUE

C  COMPUTE AVERAGES.
      FNSG =NSG

C  THESE FACTORS ARE SCALED TO PRESERVE ACCURACY.
      IGROPS(LAST +1) =ALR /FNSG  * 10000.0
      IGROPS(LAST +2) =AAC /FNSG  *10000.0
      IGROPS(LAST +3) =AAG /FNSG *10000.0
      IGROPS(LAST +4) =ASIQ /FNSG *10000.0
      IGROPS(LAST +5) =ASEX
    1 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE VJF(NOGP,ISTAGE,IVJFSW,IVJFP,VJFE)
C   THIS ROUTINE MODIFIES THE OUTCOME OF THE EXPERIMENT BY CHANGING THE
C      SUBJECT'S PARAMETERS IN A MANNER PARALLELING THE REAL WORLD
C      VALIDITY JEOPARDIZING FACTORS.
      COMMON ACNGE(9,12),ASCORE(9,12),COST(4),ICARD,IGNEQ(13),IGPIS,
     1IGROPS(250),IGSW(12,6),ISGN(130),IPS,IVJFGW(10,12),IY,KOEXP,LGNEQ,
     2LTS(130),NG,NGAVE,NMEM,NOSS,NSG,NSGR(12),NSP,NTST(12),NTSTT(12),
     3NTYPS,SP(2080),SSCH(9,12),SSSC(9,12),SUMEFF(520),TSCORE(9,130),
     4TSCOST
C   ISTAGE IS THE PHASE OF THE EXPERIMENT THROUGH WHICH THE GROUP IS
C      PASSING.
C   IVJFP CONTAINS THE NUMBER OF THE PARAMETERS AFFECTED BY EACH VJF.
C   IVJFSW IS A VECTOR OF SWITCHES FOR THE VJFS (ON =1,OFF =0).
C   NOGP IS THE NUMBER OF THE GROUP WHICH IS BEING PROCESSED.
C   VJFE CONTAINS THE PERCENT A PARAMETER IS TO CHANGE AS A RESULT OF
C      AN ENVOKED VJF.
      DIMENSION IVJFP(10,4),IVJFSW(10),IWKF(10),PARLIM(16,2),
     1 SREG(3),VJFE(10,4)
      DATA SREG/4.0,4.0,4.0/
C   SREG IS AN ARRAY OF LIMITS FOR DETERMINING STATISTICAL REGRESSION.
      CNGMEM =.03
      DATA PARLIM/60.0,9*0.0,-1.0,5*0.0,140.0,2*.5,8*1.0,5*100.0/
C   EXTRACT THE APPLICABLE VJF GROUP.
      IWVJF =IGSW(NOGP,ISTAGE)
      IF (IWVJF.EQ.0) RETURN
C   EXTRACT THE INDIVIDUAL VJF'S AND BUILD LIST.
      NAVJF =0
      K =0
      DO 1 I =1,10
```

```
      IF (IWVJF.EQ.0) GO TO 2
C   EXTRACT ONE VJF.
      K =K +1
      N =IWVJF
      IWVJF =IWVJF/10
      IVJ =N -IWVJF *10
C   IS SWITCH TURNED OFF?
      IF (IVJFSW(IVJ).EQ.0) GO TO 1
C   HAS THIS VJF BEEN ACTIVATED THE MAXIMUM NUMBER OF TIMES?
      IF(IVJFGW(IVJ,NOGP).LE.0) GO TO 1
C   DECREASE COUNT.
      IVJFGW(IVJ,NOGP) =IVJFGW(IVJ,NOGP) -1
C   ADD VJF TO LIST.
      NAVJF =NAVJF +1
      IWKF(NAVJF) =IVJ
      GO TO 1
    1 CONTINUE
C   ARE ALL VJF'S ACTIVE?
    2 IF (K.EQ.NAVJF) GO TO 3
      IF (NAVJF.NE.0) GO TO 4
      IGSW(NOGP,ISTAGE) =0
      RETURN
C   UPDATE ACTIVE VJF LIST FOR THIS GROUP AND EXPERIMENT STATUS.
    4 I =NAVJF -1
      J =IWKF(NAVJF)
    6 IF (I.LE.0) GO TO 5
      J =J +IWKF(I) *10
      I =I -1
      GO TO 6
```

```
C   RESTORE CURRENT ACTIVE VJF LIST.
    5 IGSW(NOGP,ISTAGE) =J

C   PROCESS EACH VJF.
    3 DO 7 I =1,NAVJF
      KVJF =IWKF(I)

C   DETERMINE THE PARAMETERS AFFECTED.
      DO 8 L =1,4
      KPAR =IVJFP(KVJF,L)

C   IS THIS THE LAST PARAMETER?
      IF (KVJF.GT.8) GO TO 19
      IF (KPAR.EQ.0) GO TO 7

C   MODIFY ALL MEMBERS OF THE GROUP.
   19 IDXM =(NOGP -1) *(NSG +NGAVE)
      DO 9 J =1,NSG

C   SELECT A MEMBER.
      IND =IGROPS(IDXM +J)

C   HAS MEMBER BEEN DROPPED?
      IF (LTS(IND).EQ.4) GO TO 9
      IND1 =IND -1
      IF (KVJF.GT.8) GO TO 18

C   IS THE PARAMETER ARRAY OR MEMORY ARRAY TO BE MODIFIED?
      IF (KPAR.GT.100) GO TO 10

C   IS PARAMETER VALID?
      IF (KPAR.GT.NSP) GO TO 9

C   MODIFY THE PARAMETER.
      CHANGE =VJFE(KVJF,L)
      ITEM =IND1 *NSP +KPAR
      CPAR =(CHANGE +1.0) *SP(ITEM)
```

```
C   IS VALUE WITHIN RANGE?
       IF (CPAR.GT.PARLIM(KPAR,1)) GO TO 11
       CPAR =PARLIM(KPAR,1)
       GO TO 12
    11 IF (CPAR.GT.PARLIM(KPAR,2)) CPAR =PARLIM(KPAR,2)
    12 SP(ITEM) =CPAR
       GO TO 9

C   MEMORY IS TO BE CHANGED.
    10 ITEM =IND1 *NMEM

C   IS THIS STATISTICAL REGRESSION?
       IF (KVJF.EQ.6) GO TO 13

C   ASSUME THIS VJF IS TESTING.
       KPAX =KPAR -108
       VALUE =SUMEFF(ITEM +KPAX) *(1.0 +VJFE(KVJF,L))

C   ASSUME PROPER RANGE.
       IF (VALUE.GT.0.0) GO TO 14
       VALUE =0.0
       GO TO 15
    14 IF (VALUE.GT.100.0) VALUE =100.0
    15 SUMEFF(ITEM +KPAX) =VALUE
       GO TO 9

C   PROCESS STATISTICAL REGRESSION.
C   EXTRACT VALUE BEING MODIFIED.
    13 IVAL =KPAR -109

C   LR =1, AC =2, AG =3.
C   WHAT IS THE GROUP VALUE.
       IF (IVAL.GT.3) GO TO 9
       IF (IVAL.LT.1) GO TO 9
       GPVAL =50.0
       SUBVAL =SUMEFF(ITEM +1 +IVAL)
```

```
C   IS SUBJECT VALUE AN EXTREME?
       IF (SUBVAL.GT.GPVAL -SREG(IVAL)) GO TO 16
       SUBVAL =SUBVAL *(1.0 +VJFE(KVJF,L))
       GO TO 17
    16 IF (SUBVAL.LT.GPVAL +SREG(IVAL)) GO TO 9
       SUBVAL =SUBVAL *(1.0 -VJFE(KVJF,L))
    17 SUMEFF(ITEM +1 +IVAL) =SUBVAL
       GO TO 9

C   PROCESS INSTRUMENTATION AND MORTALITY.
    18 IF (KVJF.EQ.10) GO TO 7

C   INSTRUMENTATION IS NOT IMPLEMENTED.
C   PROCESS MORTALITY.

C   RECOVER THE SUBJECT'S RANDOM NUMBER THE PARAMETER LIST.
       RVAL =SP(IND *NSP -1)

C   SCALE VALUE TO 0 TO 1 RANGE.
       MVALT =RVAL/NTYPS
       RVAL =(RVAL -MVALT*NTYPS) /NTYPS

C   DETERMINE IF SUBJECT IS A DROP-OUT.
       IF (RVAL.GE.VJFE(9,1)) GO TO 9
       LTS(IND) =4
       NSGR(NOGP) =NSGR(NOGP) -1
     9 CONTINUE
     8 CONTINUE
     7 CONTINUE
       RETURN
       END
```